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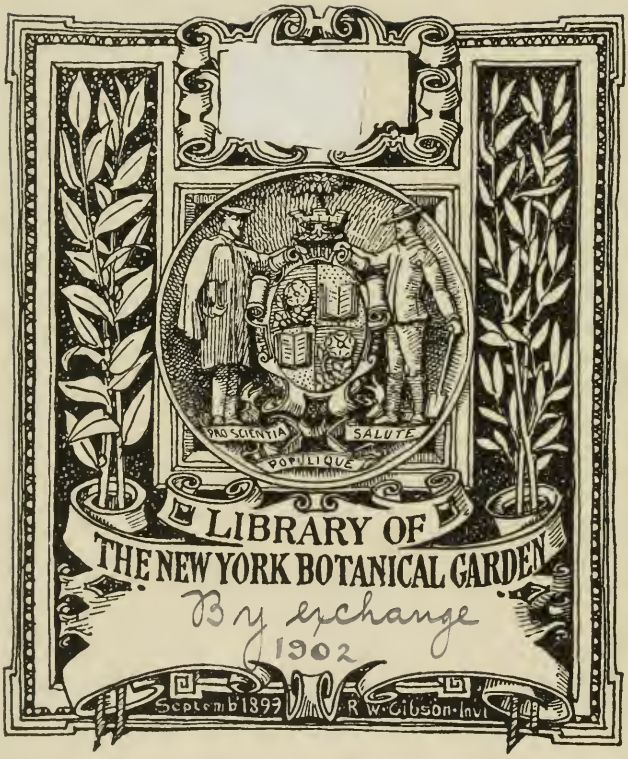
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BUREAU OF FORESTRY—BULLETIN No. 32.

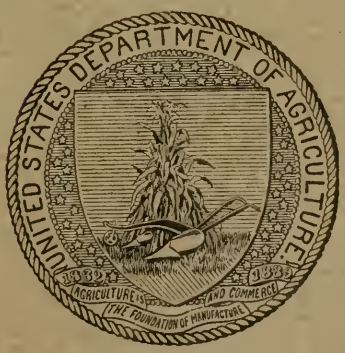
GIFFORD PINCHOT, Forester.

A WORKING PLAN FOR FOREST LANDS NEAR PINE BLUFF, ARKANSAS.

BY

FREDERICK E. OLMSTED.

FIELD ASSISTANT, BUREAU OF FORESTRY.



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LOBLOLLY PINE AND HARDWOODS IN MIXTURE ON A PINE FLAT.

U. S. DEPARTMENT OF AGRICULTURE.

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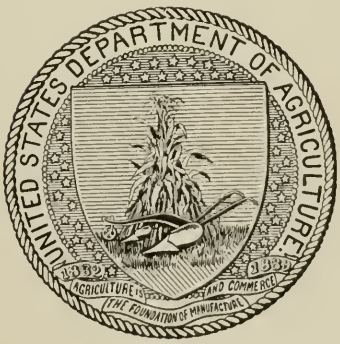

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Forestry,
Washington, D. C., March 12, 1902.

Sir: I have the honor to transmit herewith a report entitled "A Working Plan for Forest Lands near Pine Bluff, Arkansas," prepared by Frederick E. Olmsted, field assistant in the Bureau of Forestry, and to recommend its publication as Bulletin No. 32 of this Bureau. This working plan is now in operation.

Very respectfully,

Gifford Pinchot,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

INTRODUCTION.

A working plan is simply a scheme of management for a forest tract. To prepare it a thorough study must be made not only of the present character of the forest, but also of its capacity to furnish future yields and of the conditions which will govern the transport and marketing of the timber cut. Upon this study is based a systematic plan for lumbering. The point of view is purely practical; the purpose is to prescribe cuttings which will not only pay, but will also tend toward the gradual and sustained improvement of the forest. It is a business policy recommended after an expert investigation.

In the preparation of a working plan two important points to be determined are: (1) The amount of timber standing; (2) the rate at which the principal species are growing. This known, it is possible to estimate what will be the yield of timber after a given number of years, and also to calculate the amount of merchantable timber which the forest is capable of producing each year, so that, if desired, the annual cut may be made equal to the annual production and a sustained yield of timber be assured.

On the tract of the Sawyer & Austin Lumber Company one of the chief objects in making a working plan was to determine whether the present tract is large enough to furnish a sustained yield equal to the yearly capacity of the mill, and if not, to estimate the additional area necessary to secure such a result.

The stand of timber was determined in the following way: Strips 10 chains long, of which each 10 chains in length made an area of 1 acre, were run on compass courses through the forest, and on these strips the diameters of all pine down to 2 inches and hardwoods down to 10 inches were measured with the calipers. These measurements were recorded upon tally sheets, a separate sheet for each acre, and upon them notes were made of the silvicultural condition and the merchantable quality of the stand. The strips were so run through all types of forest as to afford a basis for a close estimate of the stand. These "valuation surveys" covered 1,900 acres, or about 2 per cent of the total forest area.

The table giving the merchantable contents of pine in board feet was constructed by scaling the logs of 625 felled trees. The rate of growth

for Shortleaf and Loblolly Pine was calculated from "stem analyses" of the same number of specimens. These stem analyses included the following measurements:

Diameter at 4.5 feet from the ground.
Diameter on the stump and at the top of each log, inside and outside the bark.
Height of stump.
Length of each log and of the crown.

The rings were counted on the stump and at the end of each log, and the distance to each ten-year point from the bark was measured. From these measurements it was possible to ascertain the rate of growth of the trees both in height and in diameter. No investigations were undertaken of the rate of growth of the hardwoods.

The field expenses necessary to the preparation of this working plan were borne by the Sawyer & Austin Lumber Company.

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A WORKING PLAN FOR FOREST LANDS NEAR PINE BLUFF, ARKANSAS.

PART I.

THE TIMBERLANDS.

GENERAL DESCRIPTION.

The timberlands of the Sawyer & Austin Lumber Company are situated in portions of Grant, Jefferson, and Saline counties, Ark., and lie south of the Arkansas River about 100 miles from where it empties into the Mississippi. They comprise 105,000 acres, about 5 per cent of which is bare of merchantable timber. The property is very much cut up by farm lands and other private holdings.

The tract is generally flat, except in the extreme northern portion, where it is somewhat hilly. The elevation above sea level varies from 200 to 300 feet. All the principal streams flow in a southerly direction. The most important are Saline River, Lost Creek, Hurricane Creek, and Darysaw Creek, each of which has a very slight fall and an exceedingly winding course. During the rainy season of March and April, and after any heavy rainfall, the streams overflow their banks and flood the bottom lands, making travel difficult or impossible.

The tract is, for the most part, abundantly supplied with roads, but as a rule these are poorly made and badly cared for, and are practically impassable in wet weather.

With the exception of a small area in the northern portion of the tract the geological formation is alluvial. The soils are deep sandy loams and loamy sands, and contain a slight admixture of clay. Beds of gravel or pebble are very rare. On the small area in the north, igneous rocks, chiefly granites, occur to some extent, and local deposits of bauxite have recently been discovered and are now being mined. Where granites occur the soils are shallower than on the alluvial plain.

Both the low, flat country of the south and the hilly land of the north are covered almost entirely by virgin growth of mixed pine and hardwoods, while a pure hardwood forest is characteristic of the bottom lands along the streams.

MARKET, TAXES, AND TRANSPORTATION.

Although present prices for Yellow Pine are somewhat lower than usual, there is a very good demand for all descriptions of pine lumber. The higher grades are shipped to the States of the Middle West or

East, while the lower grades find a ready market in the Southwest. There is every reason to believe that this demand will steadily increase.

The average taxes amount to about $18 per $1,000 of valuation, or 1.8 per cent. As yet no assessment value has been placed on cut-over lands, but it is expected that these will be assessed at $1 per acre. This is much too high and plainly unfair, since they are hard to sell at 50 cents per acre. Taxes on cut-over lands play a very important part in conservative lumbering, and it is to be hoped that every effort will be made to secure just and fair taxation.

An excellent system of transportation is already in operation. It consists of a main line of railroad with radiating branch lines. The main line, of which 12 miles are already completed, runs from the mill at Pine Bluff through the center of operations in the woods, and is intended to serve eventually as a freight and passenger line connecting Pine Bluff with Sheridan and Benton. The "spurs," or branch lines, are merely temporary, and are built in such a way that after serving their purpose by transporting to the main line the timber from the area which they tap, the ties and rails may be taken up and laid again through that next to be logged.

In this way the logs are transported by rail direct to the mill. This system has proved to be the best one under the local conditions.

LUMBERING.

The lumbering done upon the tract previous to its purchase by the Sawyer & Austin Lumber Company was insignificant. Only over very small areas in the hardwood bottom lands Cow Oak and White Oak had been cut for staves, and on the pine lands little patches here and there were thinned out long ago for the small mills. In the spring of 1900 the company began lumbering about 10 miles from Pine Bluff, and cuttings have since continued steadily. It is now intended to carry on the lumbering both winter and summer until the whole tract of 100,000 acres has been cut over.

Following the recommendations of Mr. Griffith, of the Bureau of Forestry, who made the preliminary examination of the tract, pine is now being cut to a diameter limit of 18 inches on the stump. The trees are cut at about 18 inches from the ground, and the last log-cut is made well up in the crown, generally at a diameter of about 14 inches. As the hardwood trees growing in mixture with the pine are of inferior quality, it is only very rarely that one is felled. Lumbering of the hardwoods on the bottom lands has not as yet been begun.

The logs are either snaked or hauled to the railroad by horses, or skidded to the tracks and loaded upon cars by a steam skidder, the latter method having so far proved cheaper and fairly satisfactory. (See Pl. IX, fig. 2.) The company's mill at Pine Bluff is expected to saw annually from 40,000,000 to 50,000,000 feet of lumber.

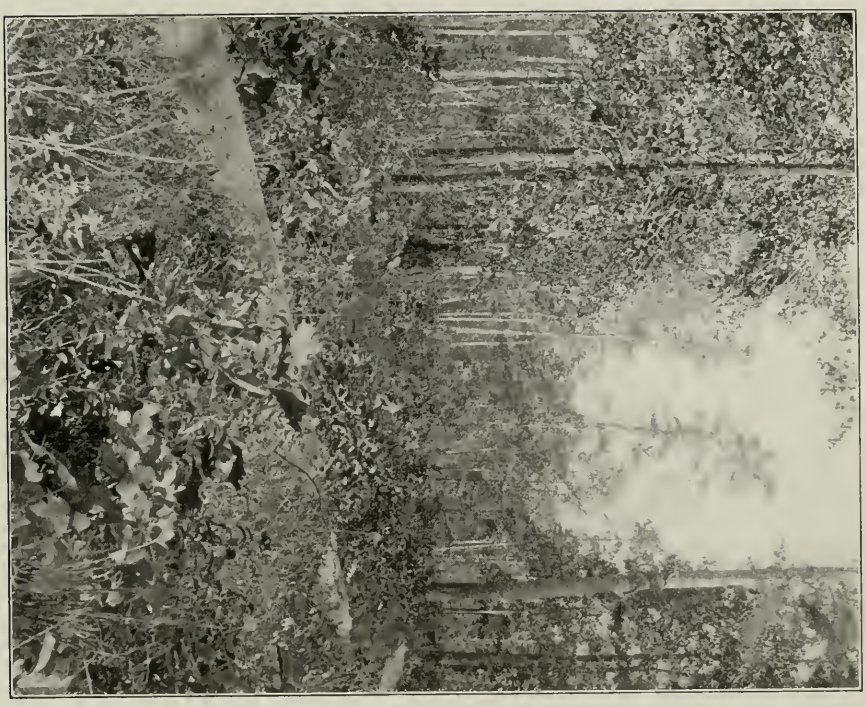

FIG. 1.—BLANK CAUSED BY LUMBERING.

FIG. 2.—HARDWOODS ON A PINE RIDGE.

FIG. 1.—PINE RIDGE CUT OVER TEN YEARS AGO. RUN OVER BY FIRE.

FIG. 2.—PINE FLAT CUT OVER TEN YEARS AGO. RUN OVER BY FIRE.

FIRE: ITS INFLUENCE UPON THE FOREST CROP.

Conservative lumbering can never be successfully carried out in this region unless precautions are taken against fire.

On the valuation surveys notes were kept of fire damage, and it was found that only 5 per cent of the total area had escaped more or less serious fire during the last ten years. In this region the fires are seldom more than ground fires, consuming the leaf mold, grass, and other ground cover, seedlings, and young growth of all kinds, but very rarely burning a tree which has passed the sapling stage. Where the flames rise to a height of 10 feet the fire is considered severe.

Only a small proportion of the mature pine has been damaged, since the bark of both the Shortleaf and the Loblolly Pine possesses excellent resisting power. On some badly burned areas examined all young growth below about 20 feet in height has been completely destroyed. Yet, although all the mature pine and the high poles had been very severely scorched and charred, often to a height of 40 feet from the ground, they were apparently perfectly sound and healthy, nor had their growth been appreciably checked.

In many localities, however, the mature pine has been cut into, 3 or 4 feet from the ground, to determine whether the wood splits easily and hence is suitable for the making of shingles. A notch about a foot square and 6 inches deep is chopped out, and if the wood is found to be unsuitable the tree is left standing. From this wound the pitch flows freely, hardening in irregular masses on the trunk, and thus offering the best of fuel for the next fire. As a rule, fire will burn in such a tree for some time, often eating a large hole halfway or more through the trunk and weakening it to such an extent that it succumbs to the first hard wind. A large part of the "down" timber on the tract has been thrown in this way. Where litter and dry branches collect around the foot of a tree the danger is increased.

The mature oaks, especially White and Post Oak, are much more sensitive to fire than the mature pines, and are often killed simply by a severe scald. The same is true of Hickory and Sweet Gum. But as these hardwoods growing on pine lands are of but little commercial value, no great loss is caused by their death.

In the case of young growth, fire is very disastrous. When fire reaches the top of a young pine the tree is, with rare exceptions, killed. An ordinary ground fire, therefore, is pretty sure to kill all pine under 6 feet in height and 5 or 6 years old. Seedling growth of all kinds is consumed down to the roots. But the young hardwoods, and to a large extent both Loblolly and Shortleaf Pine, have the power of sending up sprouts after fire. These sprouts come up from the roots just below the surface, and if not interfered with there is every reason to believe that they will grow into timber trees. No evidence is at hand to show just how many times a young pine may be killed

back by fire and still be able to sprout, but it may be safely assumed that it can do so after two or three such setbacks. Both Loblolly and Shortleaf can produce these shoots up to the age of 15 or 20 years.

These fires, occurring as they do every three or four years, have had a disastrous effect on the character of the forest. The older trees, both pine and hardwood, continue to live for a number of years at least, but reproduction is checked. Not that no young growth whatever succeeds; almost any cut-over area which has been swept by repeated fires proves the contrary. Many pine and hardwood seedlings will be found growing up in spite of the fires, favored by chance or some local condition. But such young growth is meager and very inferior to what would be obtained if fires were kept out. Areas cut perhaps twenty years ago, and visited by frequent fires since, are generally covered with open groups of hardwood saplings, and in these groups, as well as scattered about through the whole area, is a sprinkling of young pines, which at times form open and scraggy groups by themselves. Such a sparse, open, and irregular growth is bound to be of very little commercial value. The saplings will grow up into badly formed trees with many low branches, and the timber produced will be knotty and inferior.

On the other hand, in localities which have been exempt from fire large, dense groups of young pine and hardwood have sprung up. Reproduction of this kind may be seen on limited areas in several parts of the tract. If fire were excluded, it is perfectly reasonable to expect that this condition would obtain generally, and that such groups would gradually spread until they had occupied most of the cut-over area. This young growth would produce tall, straight trees, free from branches, and containing the most valuable kind of timber. Even with ample protection against fire, the whole cut-over area would of course never grow up to a dense, even-aged growth of pine so long as a large proportion of mature hardwood remained standing after the lumbering; but the percentage of pine in the young growth would be largely increased, and the commercial value of the future forest would be much higher.

Apart from the damage done by fire to the young growth, the forest as a whole suffers very severely from the complete destruction of the humus or leaf mold. It is a noticeable fact that the soil throughout the tract is covered by so thin and scattered a layer of leaves and needles as to be almost entirely bare. Fire consumes the leaf litter completely every time it passes over the ground, and in so doing destroys the best fertilizer and protector of the forest soil, leaving it exposed to the deteriorating action of sun, wind, and rain. As a consequence, the rate of tree growth suffers.

By far the largest number of fires are started intentionally by people owning farms or small bodies of timber surrounded by or bor-

dering on the company's land. They are set in order to burn away the underbrush and open the woods for hunting and hog ranging. Thirty or forty years ago the whole forest was burned over regularly each year in order to improve the grazing, but this custom has been but little followed of late. A few of the fires are caused by the carelessness of loggers or campers.

The effect of fire on this forest may be summed up as follows:

(1) The young growth of all species, but especially that of pine, is very seriously damaged or totally destroyed.

(2) Mature and middle-aged trees are damaged to some extent.

(3) The soil is constantly impoverished through the destruction of the leaf litter.

If the forest is to be managed with a view to future crops, it is necessary to obtain young growth which will develop into a first-class stand of timber. This is impossible unless fire is kept out. A partial protection is worse than none, for if the forest be guarded for five or six years and then burned over, the fire feeds on the accumulated litter, and the damage done is much greater than if light fires occurred each year. Therefore, if protection is attempted it should be thorough.

The diagram herewith (fig. 1) is exceedingly significant. It illustrates the occurrence of pine according to diameter classes, and it reveals a peculiar irregularity in the number of trees in these classes. This irregularity is in all probability due to the damaging effects of forest fires in past years. The diagram shows the average number of trees per acre of Shortleaf and Loblolly Pine, separately and combined, of diameters from 2 to 40 inches. It will be seen that the three curves for diameters from 40 to 22 inches are quite regular, the number of trees per acre increasing steadily as the diameter decreases. At 22 inches, however, a decided break occurs, and from this point down to 14, 15, and 16 inches the same increase in the number of trees per acre does not take place. From these points down to 2 inches the increase again becomes very regular.

Now it is apparent that if no breaks occurred in the curves at the 22-inch point, the lines would have continued on as indicated by the short broken lines of the diagram, and the number of trees per acre of smaller diameter would have been much larger. In other words, the number of trees in the smaller diameter classes at the present time is insufficient to maintain the present stand of mature trees.

Loblolly Pine, when 22 inches in diameter, is about 100 years old. The curves show that the proportion of younger trees has been reduced by some disturbing influence. Such an influence is fire—not a great fire, but repeated fires of ordinary severity, such as the forest now suffers from. As the region was slowly entered by settlers these fires would begin. The trees which are now one hundred years old had by that time reached such a development that they were not affected; the injury was then, as now, chiefly to the young growth.

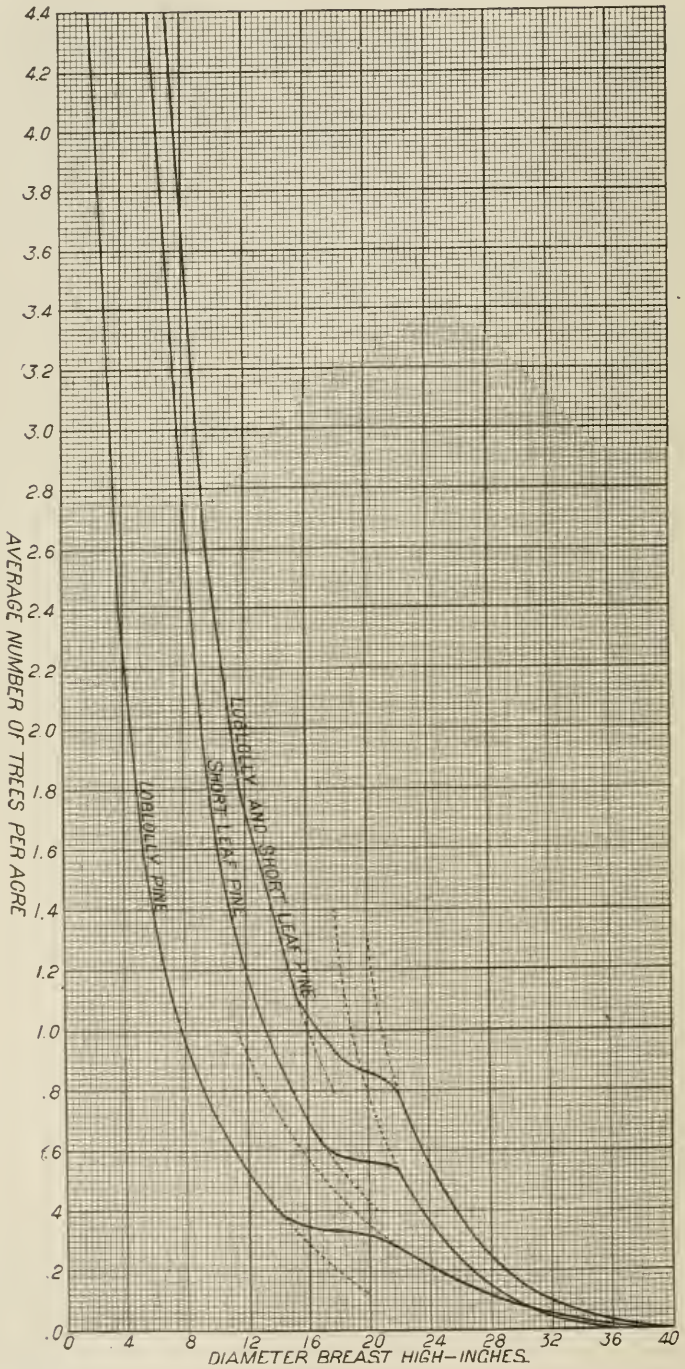

FIG. 1.—Diagram showing the number of trees per acre for Shortleaf and Loblolly Pine and for the two species combined, on a diameter breasthigh.

How old the trees must have been to escape damage would depend chiefly on the intensity of the fires. It is probable that the first ones were the most severe, from the accumulation of fuel which they would find. On the whole, one would conjecture from the condition of the forest that they began about seventy-five years ago.

It was in 1819 that Arkansas, acquired by the United States as a part of the Louisiana Purchase in 1803, received a separate Territorial organization, and in 1837 that it was admitted as a State. The settle-

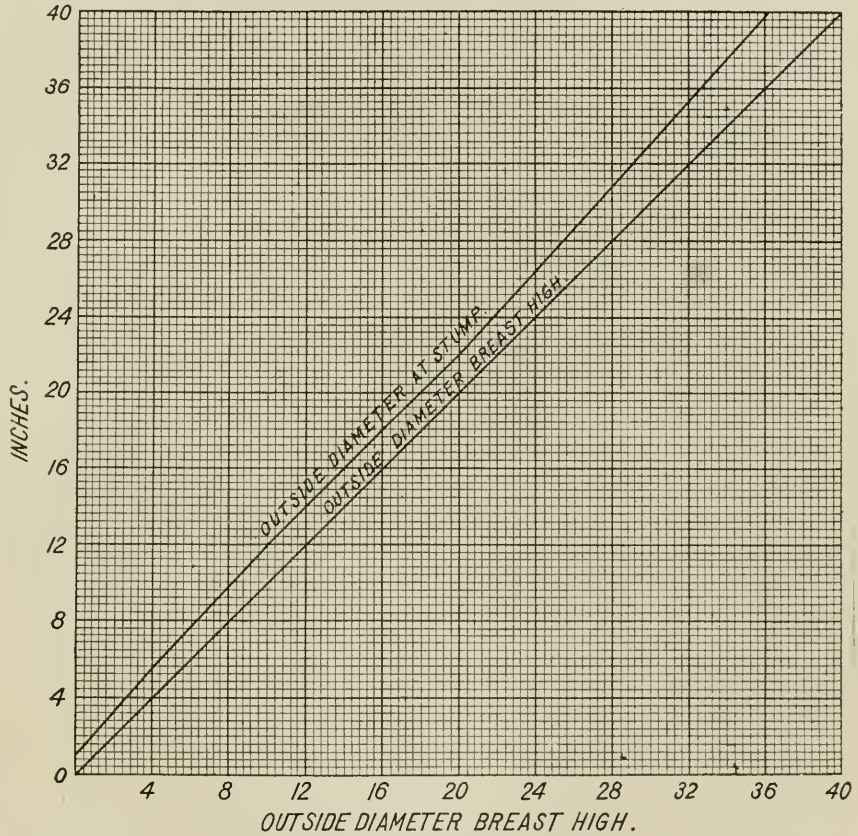

FIG. 2.—Diagram showing the relation between diameter on the stump and diameter breasthigh for Shortleaf and Loblolly Pine.

ment of the country took place, therefore, at the time when the condition of the forest leads us to infer that fires began.

GRAZING.

Cattle are not ranged extensively on the Sawyer & Austin tract and they do practically no damage to the forest. Of sheep grazing there is none.

Hogs are numerous and hog ranging is common. This should be encouraged, since the hogs eat the acorns and thus work against the

reproduction of the oak, while the damage they do to pine seedlings is trifling. They also tear up and loosen the soil, thus preparing it well for the germination of pine seed.

THE FOREST.

Although the forests of this locality are commonly known as "pine woods," pine being the principal merchantable species, a pure growth of pine very seldom occurs. Except over limited areas the pine is always in mixture with the hardwoods. On the bottom lands along the streams, pure hardwood forests occur. Several distinct types of forest growth may therefore be observed, and are distinguished by the lumbermen. These types are:

1. Pine ridge.
2. Pine flat.
3. Hardwood bottom.

Since no topographical maps of the tract were available, and since the occurrence of these types is dependent mainly upon differences in elevation and slope, it is impossible to estimate accurately the area occupied by each. From the valuation surveys, however, a rough idea of their extent was obtained, and the per cent of the total forest area each occupies is assumed to be about as follows:

	Per cent.
Pine ridge	65
Pine flat	20
Hardwood bottom	15

As each of these types has a tree growth in many ways peculiar to itself, the forest will be described silviculturally under these three headings. From the standpoint of the lumberman, however, the first two types may be thrown together under the general heading "Pine lands," since from this point of view there is very little to distinguish them. In the first place, the forests of the pine lands will be briefly described, from the standpoint of their merchantable product.

THE MERCHANTABLE FOREST.

PINE LANDS.

Occupying about 85 per cent of the total area, the pine lands form, and will continue to form, the principal source of income. Although the lands of the hardwood-bottom type contain much valuable timber, they cover too small an area to compete in commercial value with the pine lands.

The stand on the pine lands is shown by the table following, which gives the average number of trees, the percentage in mixture, and the average diameter at breastheight (4½ feet)[a] of the most important

[a] All the tables contained in this report are based on diameter measurements made at breastheight, or 4½ feet from the ground. To reduce approximately diameter breasthigh to diameter on the stump, add 2 inches to the former. The exact relation between these two diameters is shown in fig. 2.

species 12 inches and over in diameter. It may be noted here that the lumberman makes no distinction between Loblolly and Shortleaf Pine, nor is any distinction made in the trade, both being sold under the name of "Yellow Pine." In the woods, however, the lumbermen distinguish two kinds of timber—Heart Pine and Bull Pine. The latter is called also Second Growth Pine. These terms apply roughly to the two different species, the Heart to the Shortleaf and the Bull

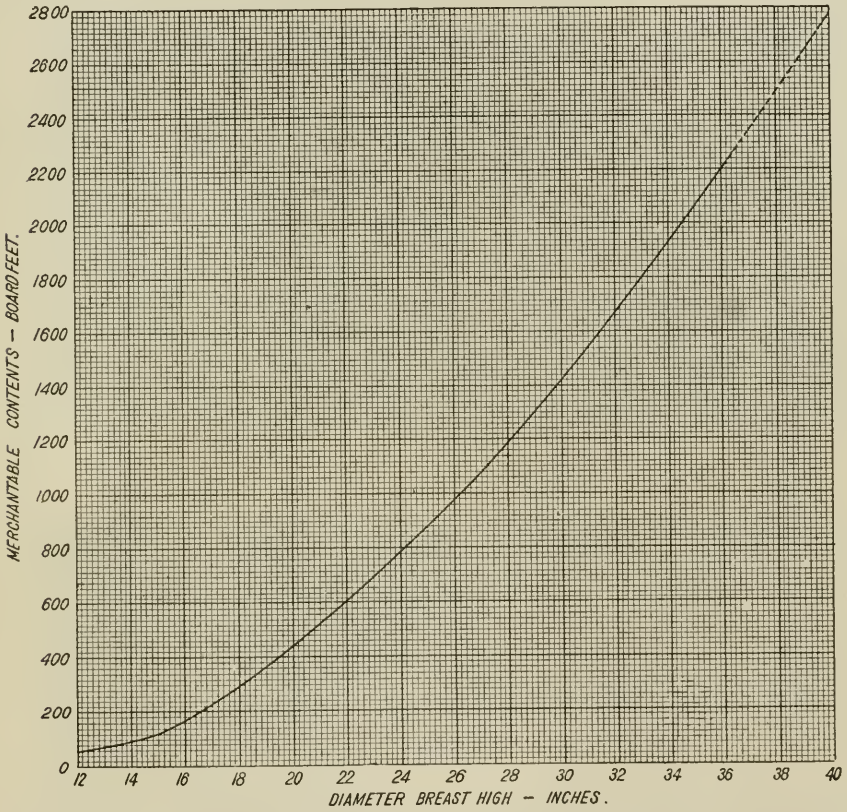

FIG. 3.—Diagram showing the merchantable contents in board feet for Shortleaf and Loblolly Pine on the basis of diameter breasthigh. (Contents by Doyle's Rule.)

to the Loblolly, because by "Heart" Pine is understood a pine whose wood is mostly heart, with very little sap; and by Bull Pine, a pine with a large amount of sapwood; and as a rule the Loblolly contains a greater percentage of sapwood than the Shortleaf. "Heart" Pine is supposed to have a thin bark and "Bull" Pine a thick bark. This rule, however, was found to be very uncertain, and can never be relied upon as a botanical distinction between the Loblolly and the Shortleaf.

TABLE No. 1.—*Average number of trees per acre—percentage in mixture and average diameter of all trees 12 inches and over in diameter breasthigh.*

PINE LANDS.

[Average of 1,745 acres.]

Species.	Average number of trees per acre.	Percentage of each species.	Average diameter breast-high.
			Inches.
Shortleaf Pine	9.91	35.66	18.9
Loblolly Pine	5.26	18.93	20.4
White Oak	3.79	13.64	20.5
Post Oak	3.28	11.80	16.5
Gum	2.09	7.52	16.3
Spanish Oak	1.25	4.50	18.0
Black Oak	.69	2.48	18.6
Hickory	.75	2.70	15.1
Other species	.77	2.77	14.5
All species	27.79	100.00	18.7
All species except pine	12.62	45.41	17.7
Pine	15.17	54.59	19.4

From this it is seen that pine forms but a trifle over 50 per cent of the total stand 12 inches and over in diameter, and that the quantity of Shortleaf Pine is nearly twice that of Loblolly. After pine, the most common trees are White Oak, Post Oak, and Gum, the Spanish and Black Oak and the Hickory being but sparsely represented.

The occurrence of Shortleaf and Loblolly Pine by diameters from 2 to 36 inches will be found in the following table:

TABLE No. 2.—*Average number of trees per acre of Shortleaf and Loblolly Pine and of the two species combined, for diameters fram 2 to 36 inches.*

Diameter (inches).	Shortleaf.	Loblolly.	Shortleaf and Loblolly.	Diameter (inches).	Shortleaf.	Loblolly.	Shortleaf and Loblolly.
2	10.55	3.90	14.45	20	0.53	0.28	0.81
3	9.87	3.53	13.40	21	.59	.31	.90
4	7.60	2.62	10.22	22	.53	.27	.80
5	5.50	1.72	7.22	23	.42	.23	.65
6	4.74	1.51	6.25	24	.33	.21	.54
7	3.59	.99	4.58	25	.29	.19	.48
8	2.83	.87	3.70	26	.24	.16	.40
9	2.39	.61	3.00	27	.18	.15	.33
10	1.66	.71	2.37	28	.13	.12	.25
11	1.40	.60	2.00	29	.08	.10	.18
12	1.22	.55	1.77	30	.07	.11	.18
13	1.04	.42	1.46	31	.03	.03	.06
14	.92	.41	1.33	32	.03	.04	.07
15	.79	.36	1.15	33	.01	.02	.03
16	.72	.35	1.07	34	.01	.02	.03
17	.62	.35	.97	35	.002	.01	.012
18	.59	.33	.92	36	.007	.01	.017
19	.58	.30	.88				

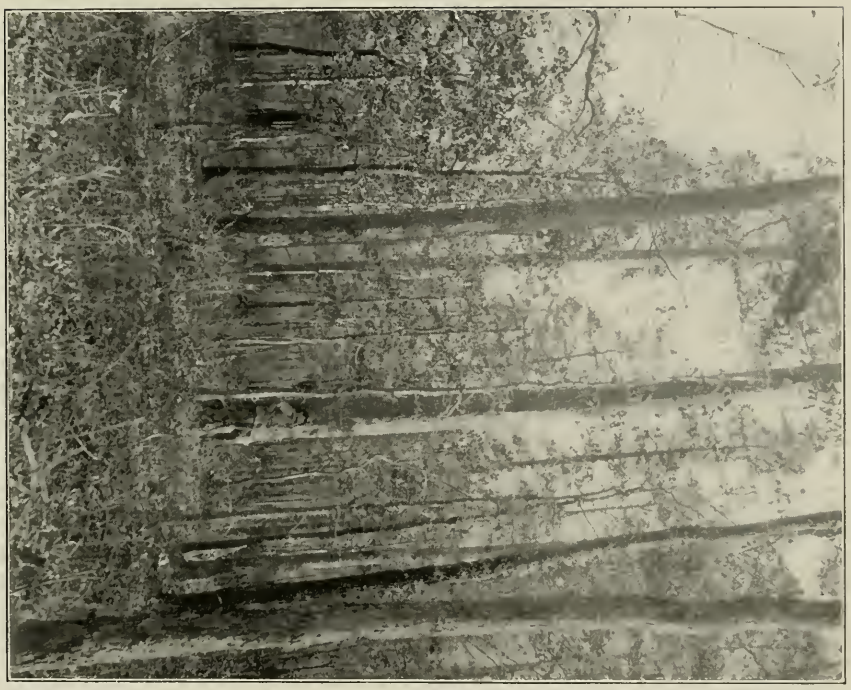

FIG. 1.—SHORTLEAF PINE ON A PINE RIDGE.

FIG. 2.—LOBLOLLY PINE ON A PINE FLAT.

The number of trees per acre below 22 inches in diameter is disproportionately small, as was shown by figure 1, which is a graphic representation of this table. The trees now approaching merchantable size are not sufficient in number to maintain the present proportion of mature timber. This has a serious influence on future yields, since it lengthens considerably the time required for the production of a second crop equal to the present one, and it shows, moreover, that the land is capable of producing a much larger stand of timber than it is now maturing.

The following table gives the average contents of standing pine in board feet, by Doyle's Rule, on a basis of diameter at breastheight, and holds good for both Shortleaf and Loblolly Pine. Figure 3 is a graphic representation of this table.

TABLE No. 3.—*Contents of pine, in board feet, according to diameter breasthigh.*

[By Doyle's Rule.]

Diameter breast-high.	Merchantable contents.	Diameter breast-high.	Merchantable contents.	Diameter breast-high.	Merchantable contents.
Inches.	*Board feet.*	*Inches.*	*Board feet.*	*Inches.*	*Board feet.*
15	120	24	780	33	1,800
16	180	25	880	34	1,930
17	240	26	980	35	2,060
18	300	27	1,080	36	2,200
19	370	28	1,190	37	2,340
20	440	29	1,300	38	2,490
21	520	30	1,420	39	2,630
22	600	31	1,550	40	2,780
23	690	32	1,680		

STAND OF MERCHANTABLE PINE.

The following table shows the average stand per acre in board feet of merchantable pine on the pine lands, cutting to various diameters:

TABLE No. 4.—*Average stand of merchantable pine per acre, in board feet, cutting to diameter limits of 12, 14, 16, 18, and 20 inches, breasthigh.*

Cutting limit, diameter breasthigh.	Average merchantable stand per acre.
Inches.	*Board feet.*
12	6,067
14	5,845
16	5,597
18	5,130
20	4,561

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The heaviest stand of pine per acre observed upon the tract lies near the southern boundary of section 27, township 5 south, range 11 west. The table below shows its composition and amount.

TABLE No. 5.—*Number of trees and merchantable contents, in board feet, for Shortleaf and Loblolly Pine on 1 acre in section 27, Township 5 south, Range 11 west, for the diameter limits of 2, 12, 14, 16, 18, and 20 inches, breasthigh.*

Diameter limit, breasthigh.	Number of trees over diameter limit.		Merchantable contents.		Total merchantable contents.
	Shortleaf.	Loblolly.	Shortleaf.	Loblolly.	
Inches.			*Board feet.*	*Board feet.*	*Board feet.*
2	4	97	.....	.....	.....
12	1	56	240	28,810	29,050
14	1	53	240	28,600	28,840
16	1	49	240	28,180	28,420
18	1	40	240	26,200	26,440
20	.....	29	.....	22,340	22,340

In the eastern part of the tract, townships 5 south, 11 west, and 5 south, 12 west, are found the heaviest stands, the western and northern portions being more lightly timbered. The heaviest stand over any considerable area is found, however, in the northwestern part of the tract—sections 3 and 4 of township 3 south, 14 west. In these sections the average stand per acre is 9,900 board feet.

THE FOREST FROM A SILVICULTURAL STANDPOINT.

PINE RIDGE.

The pine ridge type occurs on all the gently rolling or hilly portions of the tract. It includes not only the forest on the ridges themselves, but also those on the slopes and in the hollows. The so-called "ridges" are merely slight elevations with broad and nearly level tops, whose sides slope away gently at a gradient of 10 to 15 degrees. The difference in level between the hollows and tops seldom exceeds 75 or 100 feet.

Throughout this type the soils are deep, dry, and rather compact loamy sands, usually with a slight admixture of clay and with an occasional bed of gravel or pebble. Owing to frequent fires the humus is almost entirely absent, and the ground cover consists of a thin and scattered layer of needles and leaves, together with grass, weeds, and ferns. On the most open places and in irregular patches throughout the forest are more or less dense growths of Huckleberry, Laurel, Swamp Bay, and briers.

The following table shows the composition of the forest:

TABLE No. 6.—*Average number of trees per acre, percentage in mixture, and average diameters for the most important species, for trees 12 inches and over in diameter.*

PINE RIDGE.

[Average of 1,516 acres.]

Name of species.	Average number of trees per acre.	Percentage of each species.	Average diameter, breast-high.
			Inches.
Shortleaf Pine	10.52	38.39	18.9
Loblolly Pine	4.43	16.17	20.5
White Oak	3.56	12.99	20.8
Post Oak	3.31	12.08	16.5
Gum	2.01	7.34	16.5
Spanish Oak	1.27	4.64	18.1
Black Oak	.70	2.55	18.9
Hickory	.77	2.81	15.1
Other species	.83	3.03	14.5
All species	27.40	100.00	18.7
All species except pine	12.45	45.44	17.8
Pine	14.95	54.56	19.4

Pine forms a little more than 50 per cent of the total stand, and Shortleaf is more than twice as abundant as Loblolly.

In this type of forest the pines, both Shortleaf and Loblolly, occur either in very small groups or scattered about by single trees; more commonly the latter. They tower high above the crowns of the hardwoods, forming a kind of second story over the oaks, gums, hickories, etc., which occur by single trees, quite evenly distributed. Under the old hardwoods is a growth of hardwood saplings and poles, intermixed with Shortleaf and Loblolly Pine. This undergrowth is found both in large and small groups and scattered openly and irregularly, while over large areas it is entirely absent, leaving the ground clear and bare under the mature trees. Shortleaf and Loblolly Pine seedlings are exceedingly scarce in this type of forest, owing principally to the frequent ground fires, and also to the fact that they will not flourish under too great a shade from the hardwoods.

When a forest is lumbered for all merchantable pine down to 14 inches in diameter at the stump very few hardwoods are cut, and the hardwood forest remains practically intact upon the lumbered area. The forest then consists of a few mature pines which were too unsound to cut, the original stand of young and middle-aged pine under 14 inches in diameter, and an open growth of mature and middle-aged hardwoods. Scattered groups of hardwood saplings mixed with pine form the undergrowth, generally much injured by the logging. The removal of the mature pine has admitted light to the ground and fitted it for the germination of seed, while the seed-bearing capacity of the remaining trees is increased by the addition of light and room.

The object in such a forest should be to obtain a constantly increasing stand of pine and a decreasing stand of hardwoods, as the pine is the most valuable species which this locality can produce. An increase in the stand of pine can be brought about in two ways—by the removal of a large part of the hardwoods and by the exclusion of forest fires. The quality of the young growth, and consequently of the mature forest, will depend largely upon the presence or absence of fires. Even more effective would be the removal of the hardwoods. Unfortunately, however, the quality of the stand and the condition of the market will not permit of this being done at present except at a financial loss, nor is there much reason to suppose that conditions will change to any great extent in the immediate future. Every chance, however, should be taken to cut and remove all hardwoods which show a possibility of affording even a very slight profit. It should be borne in mind that every oak or other hardwood cut tends to increase the number of pine trees in the future stand.

As will be seen later on, Loblolly grows much more rapidly than Shortleaf, reaching a diameter of 12 inches in forty-four years, whereas the Shortleaf requires over sixty years. Although the "Heart" Pine, or Shortleaf, commands a slightly higher price than the "Bull" Pine, or Loblolly, the difference is only just about enough to pay for sorting it out. The Loblolly is therefore by far the more valuable tree of the two, and should be favored in every possible way. The more there is of it in the reproduction the better will it be for the future forest, because the crop will become merchantable in a much shorter time, and consequently the returns will be higher.

Unfortunately, the number of Loblolly seed trees is comparatively small on the pine ridges, and an increase in the percentage of Loblolly can be obtained only by letting as many as possible of these trees stand. In practice it will be possible to spare a tree above merchantable diameter here and there, and this should by all means be done, for every Loblolly left standing will very appreciably help along the representation of this species in the new growth. The number of Shortleaf Pine below 12 inches in diameter left after the cutting will be nearly sufficient to produce all the seed necessary for a reproduction of this species, but in some localities it will be advisable also to save a few above this 12-inch limit.

To increase the pine stand by protection against fire is entirely practicable, and will produce valuable results. It has been shown that, in the young growth, hardwoods have a decided advantage over pine where the ground is swept by repeated fires, and it is beyond doubt that if fire be kept out the percentage of pine in the young growth will be largely increased.

During the first five or six years after lumbering, if fire is kept out, the reproduction will usually appear to be composed almost entirely

FIG. 1.—LOBLOLLY POLES UNDER MATURE LOBLOLLY ON A PINE FLAT.

FIG. 2.—HARDWOOD UNDERGROWTH UNDER MATURE PINE ON A PINE FLAT.

of hardwoods; a few years later, however, a vigorous growth of young pine will be seen pushing up, and from this time on both the Shortleaf and the Loblolly will overtop the hardwoods and develop rapidly to maturity. If left to nature and protected from fire, pine is bound to be the dominant species. The locality is natural pine land, and in the past the percentage of this species was probably much greater than it is at present.

Even if such a thing were possible, it should, however, never be the object of management to exterminate the hardwoods. When present to a limited extent they serve a very useful purpose by foreing the young pine to grow up straight and free from branches, and they are also exceedingly valuable for the protection they afford the soil. As a pure pine forest approaches maturity it thins out very rapidly and the soil tends to deteriorate, as the crowns of the pine afford insufficient shelter against the action of sun, wind, and rain. If a growth of hardwoods is present under the pine the soil is much benefited, both from the shade afforded and from the humus which will gradually collect. Hardwoods, then, are a secondary but very useful factor in the forest growth. The ideal condition is that they should not be present in such numbers as to interfere with the best development of the pine, but should be sufficiently represented to afford protection to the soil and force the pine to produce clear, straight boles. In other words, they should serve as a nurse for the pine in youth and should form a second story under it as the forest grows older.

If care is taken to protect the tract from fire there is every reason to expect that after lumbering in a pine ridge forest an excellent reproduction of pine will develop, and that this reproduction will, in years to come, produce a stand of mature timber superior to that of the present day.

The stand of merchantable pine on the pine ridge type is shown below.

TABLE No. 7.—*Average stand of merchantable pine per acre on the pine ridge type, for Shortleaf and Loblolly, and the two species combined, for trees over 12 inches in diameter breasthigh.*

[Average of 1,516 acres.]

Species.	Merchantable contents.
	Board feet.
Shortleaf Pine	3,819
Loblolly Pine	2,126
Total	5,945

PINE FLAT.

On the low, almost perfectly flat lands the forest growth is in many respects very similar to that of the pine ridge type. The soils are of the same general character, but contain a larger amount of clay and are somewhat moister. Over considerable areas on these flats, and especially in the open spaces, there is a dense and often quite high growth of grass, and the usual ground cover of leaves, weeds, ferns, and huckleberries is common throughout. As on the ridges, the humus layer is exceedingly thin or entirely absent. The representation of the various species is shown by the following table:

TABLE NO. 8.—*Average number of trees per acre, percentage in mixture, and average diameters for the most important species, for trees 12 inches and over in diameter breasthigh.*

PINE FLAT.

[Average of 229 acres.]

Species.	Average number of trees per acre.	Percentage of each species.	Average diameter breast-high.
			Inches.
Loblolly Pine	10.35	33.91	19.9
Shortleaf Pine	6.21	20.35	18.7
White Oak	5.68	18.61	18.9
Post Oak	3.04	9.96	16.4
Gum	2.68	8.78	15.0
Spanish Oak	1.08	3.54	17.8
Black Oak	.65	2.13	16.0
Hickory	.63	2.06	14.7
Other species	.20	.66	13.6
All species	30.52	100.00	18.4
All species except pine	13.96	45.74	17.1
Pine	16.56	54.26	19.5

It is seen from this table that the Loblolly Pine is the most common tree on the pine flats. Where the conditions are well suited to it it is decidedly the dominant species of this type. Although Shortleaf Pine is also well represented, it is not so much at home as on the ridges; and the fresher the soil the more Shortleaf Pine gives way to the Loblolly. White Oak, Post Oak, and Gum are fairly numerous, while Hickory is very scarce. Of special interest is the proportion of pine to the hardwoods. In constitutes but little more than half the forest.

The general appearance of a pine flat forest is similar to that of the ridges, yet it differs in several particulars. As on the ridges, the pines stand high above the crowns of the hardwoods, the latter forming, as before, a kind of underwood; but instead of occurring by single trees or in small groups, the pines of the flats have a decided tendency to grow in large groups, occupying at times a quarter of an acre or

more. Scattered through these groups by single trees, or forming open groups and clumps by themselves, are oaks, gums, and other hardwoods, while both pine and hardwood reproduction is fairly abundant throughout. This reproduction is generally in the form of thickets from five to ten years of age, which prefer as a rule the more open spaces. While the reproduction of the pine ridges is usually a mixture of pine and hardwoods, on the flats the young growth occurs to a large extent in pure groups; that is, the thickets are either composed entirely of young pine or entirely of hardwoods.

The future of this type of forest, after lumbering and the removal of all merchantable pine above 12 inches in diameter, will be very similar to that of the pine ridge type, with the exception that the pine reproduction will not be hindered to such an extent by the hardwoods, as the latter are less numerous in the reproduction of the flats. If a few Loblollies over 12 inches in diameter are left standing on each acre as seed trees, the reproduction of the pine will be sufficiently cared for, and after cutting has admitted the light, seedlings of pine and hardwoods will rapidly develop. This reproduction, on account of slight variations in the nature of the soil and the characteristic grouping of the old trees, will tend to form itself into groups of pine and groups of hardwood, the latter composed almost entirely of oak.

Here again the all-important question is that of fire. What the future forest will be depends to a great extent upon the protection afforded. In this case, as on the ridge land, in spite of lumbering, fire, and the struggle with hardwoods, pine is bound to be the ruling species in the end, for the locality is natural pine land. It is simply a choice between fire protection, with a valuable future stand of pine, and no protection, with an inferior stand.

From the 229 valuation surveys taken on pine flats the average stand of merchantable pine per acre was found to be as follows:

TABLE No. 9.—*Average stand of merchantable pine per acre on the pine flat type, for Shortleaf and Loblolly Pine and the two species combined, for trees over 12 inches in diameter breasthigh.*

Species.	Merchantable contents.
	Board feet.
Loblolly Pine	4,474
Shortleaf Pine	2,172
Total	6,646

HARDWOOD BOTTOM.

Lying in narrow belts on either side of the creeks and larger streams are the hardwood bottoms. They vary in width from a quarter of a mile along the smaller water courses to over 2 miles along

Saline River, and occupy the lowest levels on the tract. At any considerable rise in the streams they are flooded, and during the rainy season (in late winter and spring) they often remain under several feet of water for weeks at a time. Slight differences in level occur throughout these bottoms, and in the depressions or sloughs standing water is always present. (Pl. VI, fig. 1.)

The soil is very deep, rich sandy loam. Its condition varies greatly with the season, because during a part of the year it is subjected to constant inundations, and then again is left dry and exposed to the action of sun and wind. In the fall the surface of the soil is exceedingly hard and "caky." Owing to frequent inundation, the leaf mold is washed away and the soil left bare. A peculiarity of these bottom lands is the dense growth of cane (*Arundinaria tecta*), which forms by far the greater part of the ground cover. This cane varies in height from 2 to 10 feet, and often grows so densely that it is hard to walk through. Grass and weeds are present to some extent.

The forest is of an entirely different character from that of the pine ridge and pine flat types. It is composed almost entirely of broadleaf species, and the trees show a very different habit of growth from the hardwoods of the pine lands. The locality is distinctly hardwood land, as ridges and flats are pine lands. From the following table the composition of the forest is evident:

TABLE No. 10.—*Average number of trees per acre, percentage in mixture, and average diameters for the most important species, for trees 12 inches and over in diameter breasthigh.*

HARDWOOD BOTTOM.

[Average of 155 acres.]

Species.	Average number of trees per acre.	Percentage of each species.	Average diameter breast-high.
			Inches.
Gum	7.59	26.86	20.9
Hickory	5.81	20.55	18.9
Cow Oak	4.45	15.72	24.6
White Oak	3.47	12.27	20.7
Holly	2.05	7.25	14.6
Ash	1.30	4.60	18.2
Loblolly Pine	.71	2.52	19.5
Basswood	.62	2.19	17.7
Shortleaf Pine	.55	1.95	18.4
Post Oak	.22	.78	16.1
Other species	1.50	5.31	18.4
All species	28.27	100.00	19.9
All species except pine	27.01	95.53	20.0

The gums, including both Sweet Gum and Black Gum, comprise about a fourth of the total stand, while the hickories (principally Shagbarks, with a very few Pignuts and Bitternuts) are next in number. Cow Oak, White Oak, and Holly are all fairly well repre-

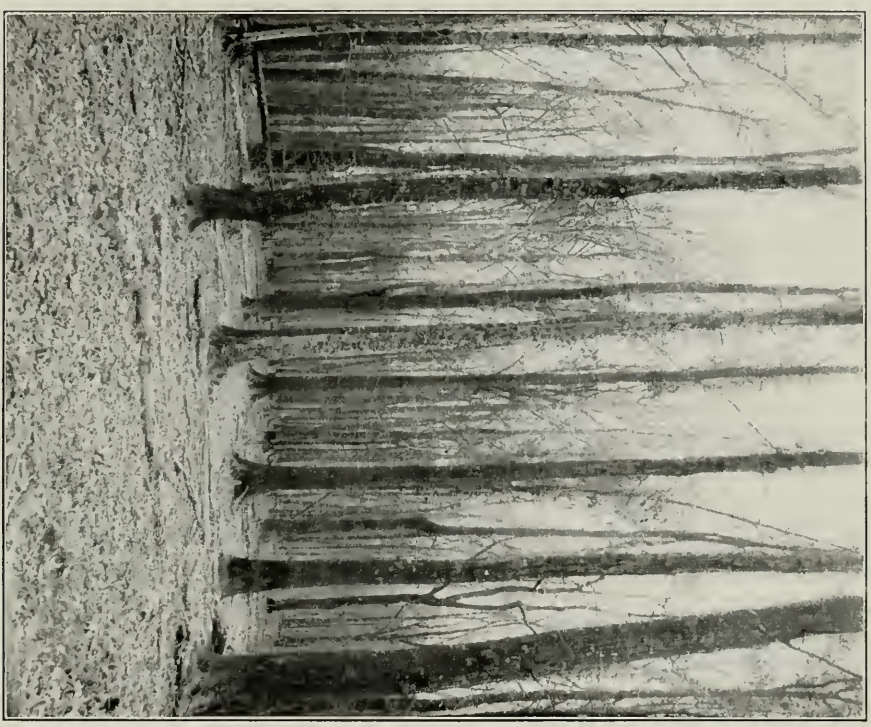

FIG. 1.—SWEET GUM AND WILLOW OAK IN A HARDWOOD BOTTOM.

FIG. 2.—COW OAK AND WHITE OAK.

FIG. 1.—A SLOUGH IN THE HARDWOOD BOTTOMS. COW OAK AND WILLOW OAK.

FIG. 2.—A HARDWOOD BOTTOM.

sented. In a typical hardwood bottom no pine is present, but along the borders of this type, where the soil is not quite so moist, a few pines occasionally creep in. This forest of broadleaf species is remarkable for its luxuriant growth and large timber.

Although the gums and hickories are the most important in point of numbers, the Cow Oaks and White Oaks will probably prove the most important commercially. The forest as a whole has the appearance of a nearly even-aged mature stand. The large, spreading crowns of the oaks slightly overtop those of the other species. Rising to nearly the same height are the gums, hickories, and ashes; and all these species are very evenly distributed over the entire bottom. Basswood is somewhat smaller in size, while the Holly and Hornbeam form a kind of scattering underwood to the main stand. The forest as a whole is dense, and but little light penetrates through the heavy crowns.

The most notable feature of this type of forest is the general absence of young growth. With the exception of scattering specimens of Sweet Gum, Holly, and Hornbeam saplings, reproduction of any description is lacking. The following facts account for such a state of things:

(1) Throughout a large part of the forest the ground is kept too dark for reproduction of any but the most tolerant species.

(2) Wherever sufficient light occurs for the germination of seedlings, these rarely succeed, because—

(*a*) The very dense growth of cane makes it almost impossible for a seedling to develop; and

(*b*) In case a seedling struggles on in spite of the cane, it rarely survives the frequent and severe floods which are sure to occur each year.

It is difficult to foretell just what the result of lumbering in the hardwood bottoms will be. In all probability no natural reproduction of the desired species can be hoped for, because of the dense cane and grass and the inundations. As soon as light is admitted by the cuttings the growth of cane and grass will be greatly stimulated. No figures can be given in this report in regard to the rate of growth of the hardwoods, as circumstances were such that it was deemed best to confine such work to the pines. If the diameter limit is kept fairly high in cutting these hardwoods (say at 20 inches), there is every reason to believe that a good second crop will be ready for the axe when the pine lands are cut over the second time. The chances of a sustained yield in future years are, however, doubtful.

The hardwood bottoms are not subject to forest fires, on account of the moistness of the ground and the sentiment of the local population. The dense growth of cane furnishes a most excellent supply of fodder for cattle, and every winter the bottoms are full of stock from the neighboring villages. In case a fire breaks out an alarm is soon given and it is quickly extinguished.

Here is a very pretty example of how interest affects the fire question. In the bottom lands the people are directly interested in protecting the grazing, and consequently the sentiment is strong against allowing fires to run in them. On the other hand, they have no particle of interest in future timber supplies or understanding of the damage which fire causes to the forest. As a consequence, there is absolutely no sentiment against fire in pine lands.

SILVICULTURAL NOTES.

BRIEF DESCRIPTIONS OF THE MOST IMPORTANT SPECIES.[a]

SHORTLEAF PINE (*Pinus echinata* Mill.).

Situation.—The Shortleaf Pine occurs most extensively on the relatively higher, very gently rolling pine ridge land. On the flats of the lower levels it generally gives way to the Loblolly. It reaches its best development on the side slopes rather than on the flat tops or in the bottoms, probably on account of the better drainage.

Soil.—A fairly light, dry sandy loam is the soil upon which this species grows to best advantage. On the low levels and in the slight depressions where the soil is moist, or even fresh, it can not compete with the Loblolly. Sometimes a little dip with a difference in level of only a few feet will bring about a change of species. The Shortleaf Pine is not exacting in regard to the mineral composition of the soil, and can flourish upon comparatively poor lands. Its chief requirement is that the soil be deep, porous, and well drained.

Tolerance and reproduction.—Direct sunlight with no shade whatever is the condition of light best suited to this species throughout its whole life. During extreme youth, however, it is capable of living under an open or very broken canopy of hardwood foliage.

Shortleaf Pine begins to produce seed when 25 or 30 years old, and occasional cone-bearing specimens but 15 or 20 years of age were met with. After the thirtieth year, at any rate, an abundant supply of seed is produced every two or three years, and under favorable conditions the reproduction of this species is marvelous.

Upon old, abandoned fields surrounded by or situated near to seed-bearing pines ideal conditions are met with. Such localities furnish the two essentials for excellent reproduction—an abundance of light and protection against fire. Seeds blow in from the neighboring trees, and at first a scattering growth of seedlings appears. This gradually becomes more closed and regular, until after eight or ten years a very dense thicket is found, which rapidly develops into a young pole

[a] These silvicultural descriptions apply simply to the particular locality for which the working plan was made, and are not to be regarded as holding good for any species over its whole range of distribution.

forest. By a natural process of pruning, the lower branches die and fall off, while the weaker trees are suppressed in the struggle for existence. Such reproduction can be seen on almost any old field, and if protected from fire it will produce a heavy and valuable stand of mature timber.

In this connection the areas known as "hurricane breaks" are of interest. Between thirty and forty years ago a tornado completely destroyed the forest in a narrow strip about half a mile wide and 4 or 5 miles long. This entire area is now grown up with a pole forest of Shortleaf and Loblolly Pine, in which hardwoods occur but rarely. The pine seed evidently blew in from the surrounding forest.

With open ground and plenty of light there is, then, no difficulty in obtaining an excellent reproduction of Shortleaf Pine. The difficulty occurs when reproduction is required under a certain amount of shade from both broadleaf and coniferous trees, upon ground where the young pine must fight for existence with a growth of oak, gum, hickory, and other hardwoods, and struggle along against the ravages of repeated fires. After the first eight or ten years, the period during which this species is capable of existing under the broken shade of broadleaf reproduction, the chances are that, unless the plant has succeeded in forcing its leading shoot up through the broadleaf growth surrounding it, it will give up the struggle and yield the ground to the hardwoods. Fortunately a large percentage of the pine seedlings usually succeed in outgrowing and overtopping the hardwoods at this important point, and from then on develop rapidly to maturity. Reproduction is also difficult on ground covered by a dense growth of grass, although a light growth seems to have no great influence.

If a good reproduction of Shortleaf Pine is wished for, protection against fire is absolutely necessary.

After lumbering under present methods, with the simple addition of a system of fire protection and the leaving of an occasional Shortleaf Pine above the diameter limit to furnish seed for reproduction, the new growth of this species should be excellent. It will appear at first as scattering seedlings under the young growth of hardwoods, and will slowly push up above the latter. As time goes on it will gradually become more dense and tend to form itself into groups. Groups will be formed because in some places the pine will have an easier time of it against the hardwoods than in others. Consequently there will be groups of hardwoods where these are too well established to be replaced by pine, and groups of pine where the latter wins.

One point in connection with the reproduction of Shortleaf Pine can not be too strongly emphasized. While there is no doubt that a young growth much superior to that which will follow the usual method of lumbering could be obtained if a number of merchantable Shortleaf Pine trees were left standing on each acre and a large quantity of the

hardwoods were cut, it is a most fortunate circumstance that even after ordinary lumbering the pine will eventually predominate, for the simple reason that the locality is one naturally suited to it.

Only those silvicultural operations are allowable which are justified by future returns. In this particular case there is no doubt that the very slight expense caused by leaving an occasional seed tree and maintaining a system of fire protection is well justified by the increase in value which will result to the future stand. Anything beyond this would involve a present expense without the certainty of an improvement in the forest which would pay for it.

Occurrence.—In the present composition of the forest the Shortleaf Pine occurs most frequently by single specimens, although found at times in small groups. It is almost invariably associated with the hardwoods, seldom forming pure stands. In the future forest the occurrence of this species should be more and more by groups, and by groups constantly increasing in size. Such will be the case if fire is kept out.

Development.—Under ordinary forest conditions this species produces a long and straight cylindrical bole, having at times a clear length of nearly 60 feet. The crown is irregular in shape, approaching the form of a truncated cone, and the stem has a tendency to fork near the top of the crown. The height of merchantable trees varies from 70 to 120 feet. Trees over 40 inches in diameter breasthigh are very rarely met with.

The accompanying diagrams illustrate the growth of the Shortleaf Pine. They are simply graphic presentations of the figures obtained from the stem analyses.

Relation of diameter to height.—This curve shows the relation between the diameter and the height growth of Shortleaf and Loblolly Pine, since the two species exhibit no marked difference in this respect. As can be seen from the curve, the height increases very rapidly with diameters up to 5 or 6 inches. The rate then diminishes in a very uniform manner until the largest diameters are reached. (See fig. 4.)

Relation of age to diameter.—The relation between age and diameter breasthigh is here shown for both Shortleaf and Loblolly Pine.

The diameter of the Shortleaf increases very regularly for the first hundred years, after which the rate of increase begins gradually to fall off. For the first hundred years the average time required to grow 1 inch in diameter is five and one-half years. It will be seen from the curve that if 12 inches be taken as the cutting limit, Shortleaf Pine first becomes merchantable after sixty-two years. (See fig. 5.)

Relation of age to height.—The height growth for both Shortleaf and Loblolly Pine is represented in this diagram. For Shortleaf the height growth is exceedingly uniform and quite rapid for the first twenty years, after which period the rate gradually diminishes. For

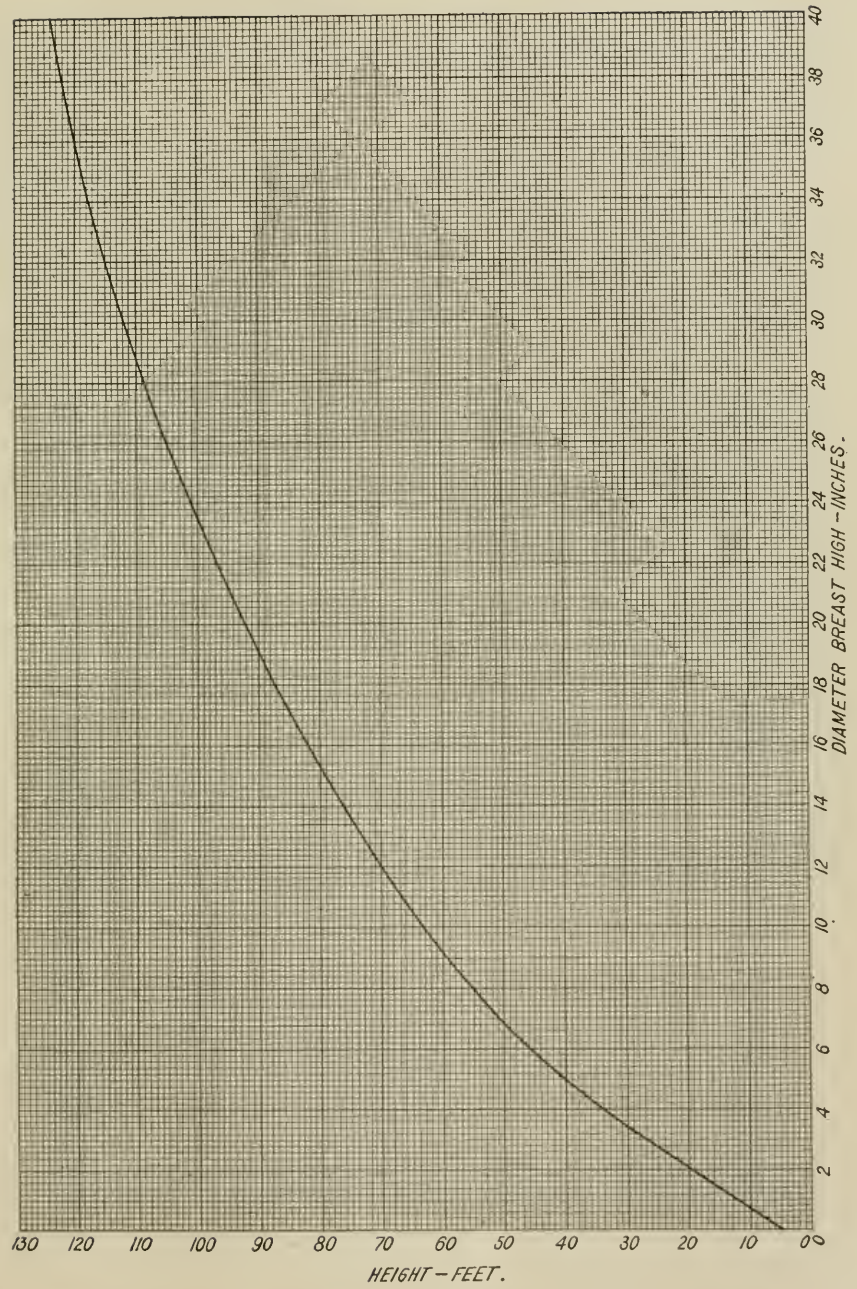

FIG. 4.—Diagram showing the height growth of Shortleaf and Loblolly Pine on the basis of diameter breasthigh.

the first one hundred years the yearly average growth in height is 0.83 foot, and for the first twenty years 1.5 feet. (See fig. 6.)

Relation of age to merchantable contents.—The curve here given

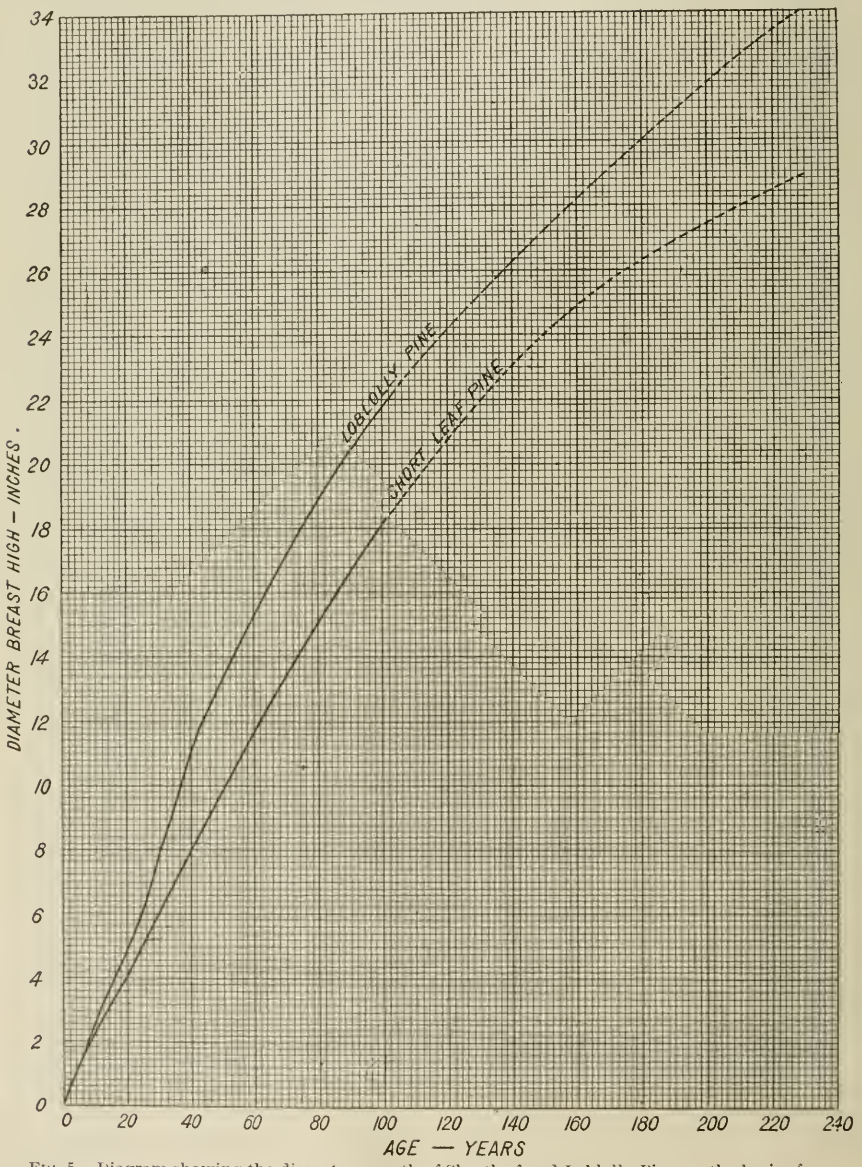

FIG. 5.—Diagram showing the diameter growth of Shortleaf and Loblolly Pine on the basis of age.

shows the volume growth in board feet for Shortleaf and Loblolly Pine, the contents being calculated according to Doyle's Rule.

Between 80 and 140 years of age the Shortleaf Pine increases very uniformly in merchantable contents, after which age the rate of

increase begins to fall off. The merchantable contents of Shortleaf Pine under 80 years of age is somewhat uncertain, as the diameters become too small for accurate calculations. Between the ages of 60 and 100 years the average yearly increase in merchantable contents amounts to 6.25 board feet, and between 60 and 200 years to 7.71 board feet. (See fig. 7.)

Relation between diameter, total height, merchantable length,[a] *crown length, and clear length.*[b] (See fig. 8.)—The principal point of interest connected with this diagram is the rapid increase in the length of merchantable timber obtained from trees of 15 to 24 or 25 inches in diameter, and the small additional length obtained from trees of greater

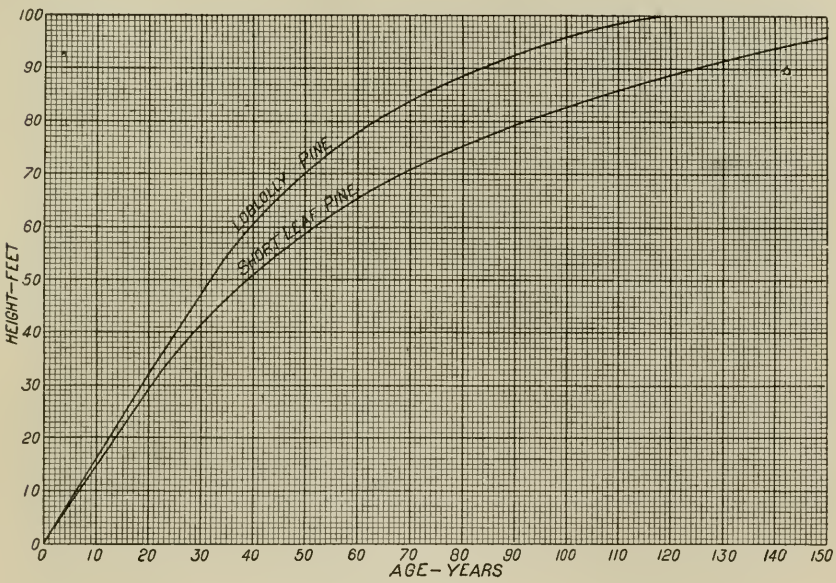

FIG. 6.—Diagram showing the height growth of Shortleaf and Loblolly Pine on the basis of age.

diameters. The merchantable length is greatest in proportion to the total height when the tree has a diameter of 20 inches. In this case a little more than one-half of the total height is merchantable.

By comparing the curves for clear length and for merchantable length it will be seen that for trees below 19 inches in diameter the merchantable length is less than the clear length, while above that diameter the reverse is true. In other words, in trees over 19 inches in diameter breasthigh (21 inches on the stump) the logs are cut up into the crowns, the distance to which the cut extends into the crown increasing as the diameter of the tree increases.

[a] Merchantable length is the total length of merchantable timber; in other words, the sum of the log lengths.

[b] Clear length is the distance from the ground to the point where the branches of the crown begin.

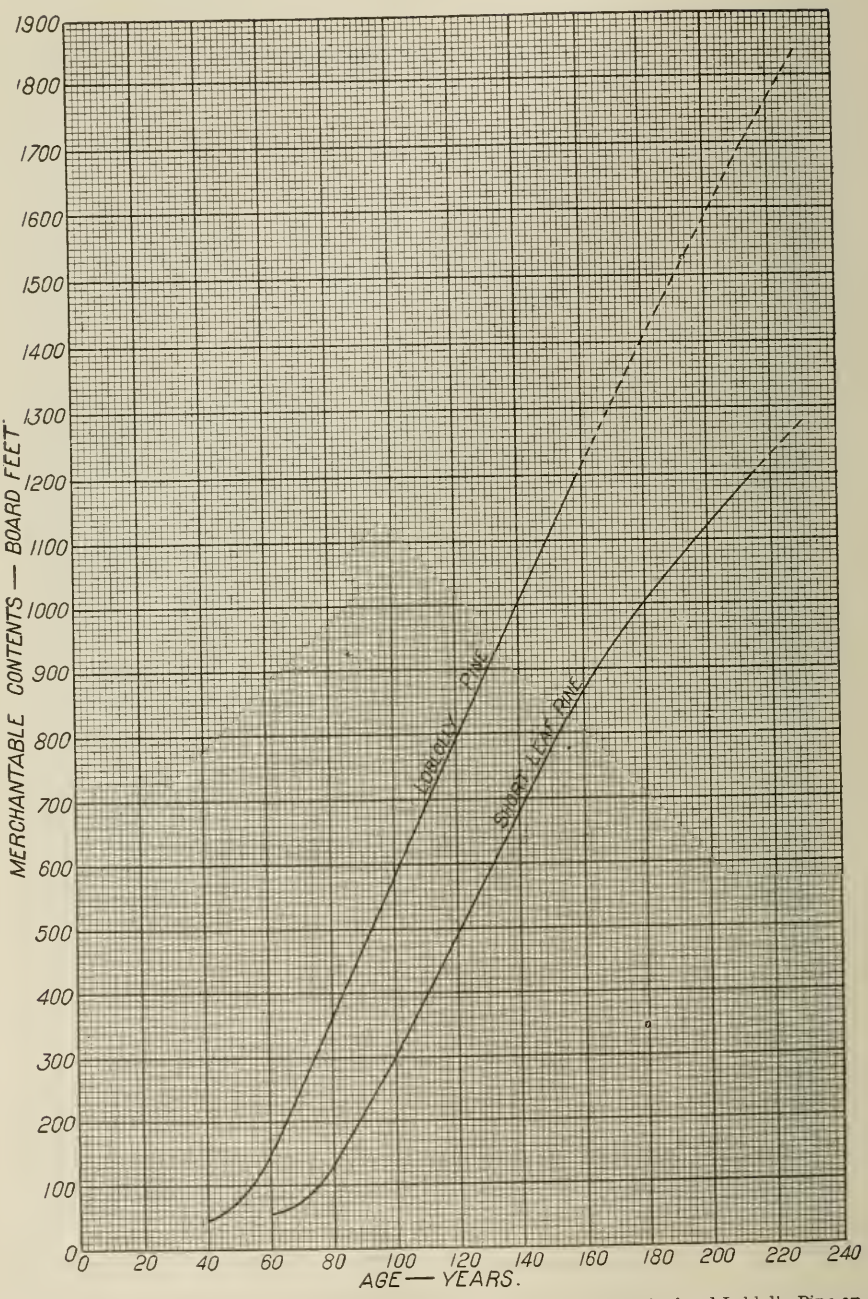

FIG. 7.—Diagram showing the merchantable contents in board feet of Shortleaf and Loblolly Pine on the basis of age. (Contents by Doyle's Rule.)

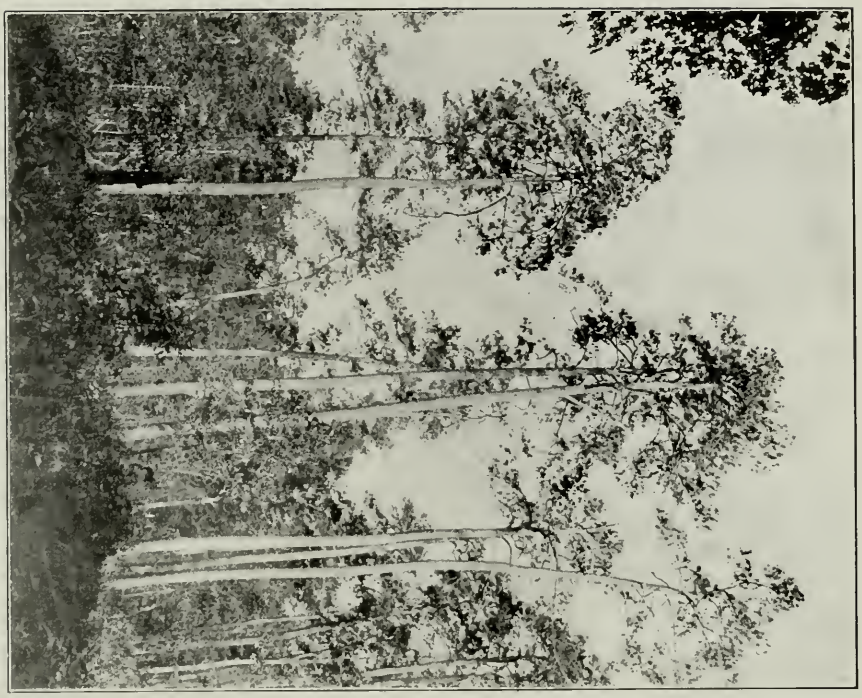

FIG. 1.—LOBLOLLY PINE.

FIG. 2.—SHORTLEAF PINE.

FIG. 1.—REPRODUCTION OF LOBLOLLY PINE IN AN OPENING.

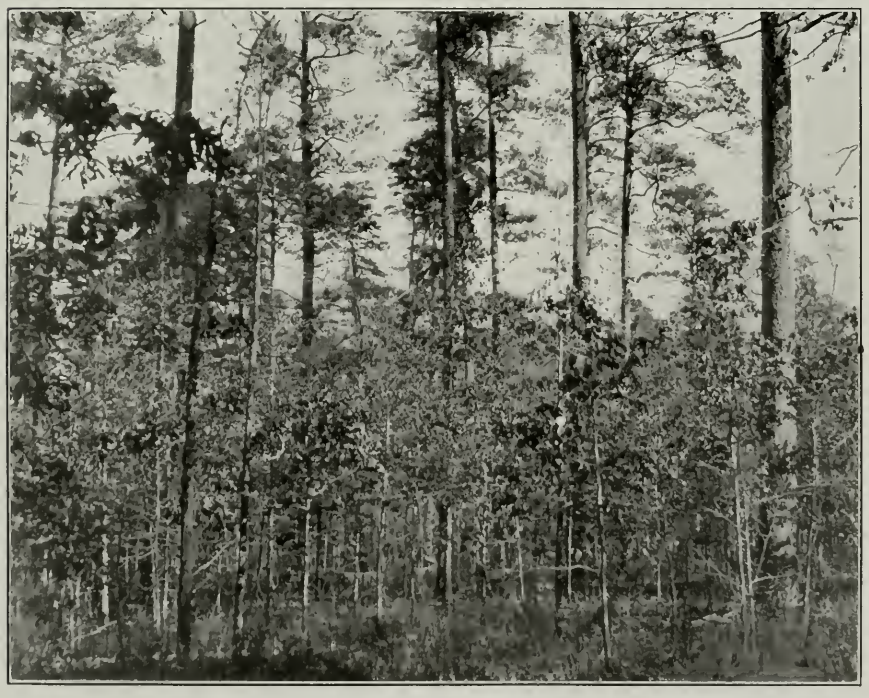

FIG. 2.—HARDWOOD REPRODUCTION UNDER LOBLOLLY.

LOBLOLLY PINE (*Pinus tæda* Linn.).

Situation.—Loblolly Pine is found at its best on the pine flats. It also occurs on the ridges, but seldom reaches its full development there.

Soil.—Soils which are favorable to the Shortleaf Pine are also most suitable to the Loblolly, with the one exception that the latter requires

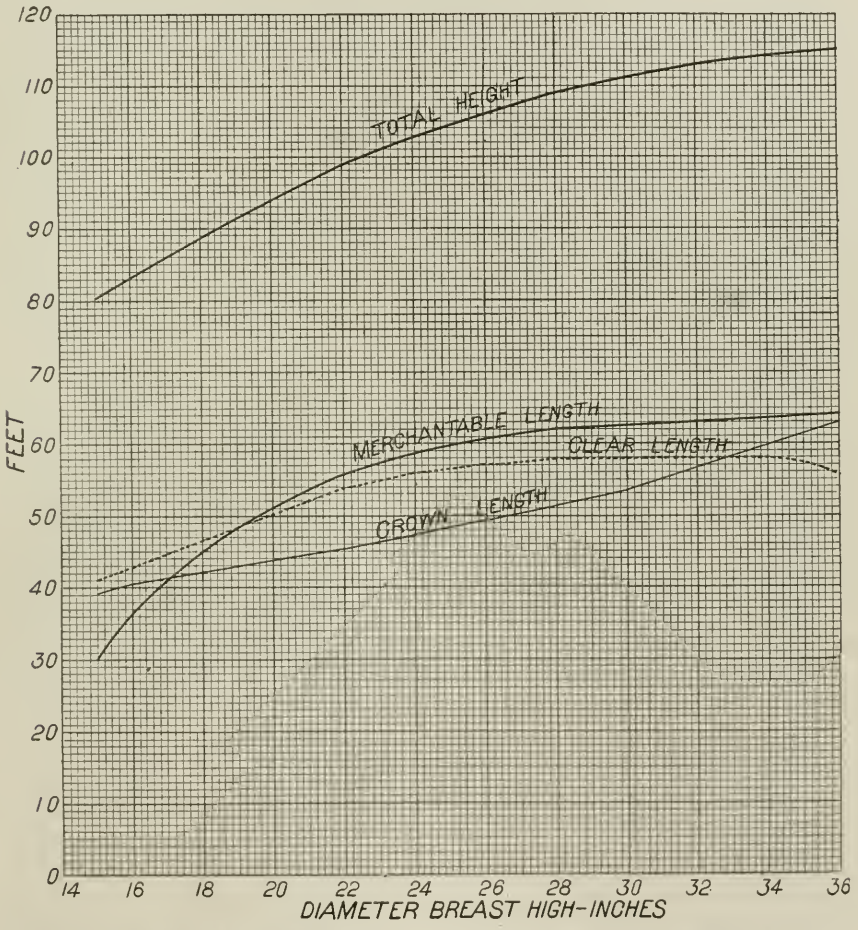

FIG. 8.—Diagram showing the relation between the total height, merchantable length, crown length, and clear length for Shortleaf Pine on the basis of diameter breasthigh.

a little more moisture. The Loblolly prefers a fresh soil, and it can flourish even in a fairly moist one. Occasional specimens are found on the higher levels of the bottom lands. Any prolonged exposure to standing water is, however, quite fatal to its growth.

Tolerance and reproduction.—In its demand for light, the Loblolly is very similar to the Shortleaf Pine, with the important exception

that under certain conditions it can tolerate a greater amount of shade during youth; where the soil conditions are favorable, Loblolly seedlings will come up under an amount of shade from the hardwoods which Shortleaf seedlings would not be able to withstand. Nevertheless, the Loblolly, like the Shortleaf, develops to best advantage under direct, open sunlight.

When 25 or 30 years of age this species begins to produce seed abundantly, and, when conditions are favorable, the reproduction is equal if not superior to that of the Shortleaf. Here, again, the young growth flourishes best in old fields, and the thickets and pole forests of Loblolly on such ground are similar in every respect to those described for Shortleaf Pine. The question as to whether Loblolly or Shortleaf will predominate on old fields depends largely on which species the locality is best adapted to. When conditions of soil are equally favorable to both species the Loblolly will generally win on account of its faster growth. But on very poor, dry ridge land the Shortleaf has the best of it. Very rarely indeed do the two species grow up into a forest where each is equally represented; one or the other will generally predominate largely in the end.

In the forest the best reproduction of Loblolly Pine is on the pine flats, because on them the mature trees are much more numerous. Here the young growth is usually found in large or small groups, always making for the open spaces, where there are any. The reproduction is in general much better than that of Shortleaf, on account of the greater tolerance of the Loblolly, and because of the smaller percentage of hardwoods in mixture where the reproduction of this species occurs. As might be expected from its greater tolerance, Loblolly gradually gains the upper hand over Shortleaf where the former has an equal chance. It must be remembered, however, that the number of seed-bearing Shortleaf Pine is far greater than that of the Loblolly, and hence the latter species is at a great disadvantage. Nevertheless, the percentage of Loblolly is gradually increasing.

Occurrence.—Loblolly occurs mostly in large groups, although occurrence by single trees is not at all uncommon. These large groups often have the appearance of miniature pure forests, as the percentage of hardwoods in mixture is small. If fire is kept out, the forest of the future should consist of much larger groups, and it can even be expected that over considerable areas the Loblolly will completely supplant the hardwoods and form very valuable stands of pure pine.

Development.—Under favorable conditions this species produces a long, straight bole, free from branches to a height of 50 or 60 feet from the ground, and has a thin and irregular crown. Its percentage of sapwood is greater than that of the latter species, as the table following shows.

TABLE No. 11.—*Per cent of sapwood in the merchantable contents of Shortleaf and Loblolly Pine, for diameters from 24 to 32 inches, breasthigh.*

Diameter breasthigh.	Shortleaf.	Loblolly.
Inches.	*Per cent.*	*Per cent.*
24	55.4	76.0
25	53.4	72.5
26	51.4	68.9
27	49.9	65.2
28	48.7	61.3
29	47.7	57.3
30	47.0	53.1
31	46.3	48.9
32	45.8	44.5

The growth of the Loblolly Pine can best be understood by a study of the curves of the various diagrams. Most of these will be found in the figures already given for Shortleaf Pine. The curves for both species are shown on the same diagram, that the two may be more readily compared.

Relation of age to diameter.—(See fig. 5.) The curve for Loblolly Pine here shows a much more rapid growth than that of the Shortleaf. For the first one hundred years the average time required to grow 1 inch is four and one-half years. If the cutting limit be placed at 12 inches, it will be seen that Loblolly reaches a merchantable size when 44 years old, or eighteen years earlier than the Shortleaf.

Relation of age to height.—(See fig. 6.) The height growth for Loblolly is rapid and very uniform for nearly forty years. After this age the rate gradually diminishes. For the first one hundred years the yearly average growth in height is 1.04 feet. As can be seen from the two curves, there is very little difference in the height growth of the two species for the first twenty years.

Relation of age to merchantable contents.—(See fig. 7.) The volume curve here given for Loblolly Pine is seen to be very nearly a straight line. The rate of increase in merchantable contents is remarkably uniform. The upper portion of this line is dotted, because so very few Loblollies over 160 years of age were analyzed that the results can not be accepted as conclusive. It is probable that in practice the actual contents of the older trees would be somewhat less than is here shown. Between the ages of 44 (when the Loblolly reaches a diameter of 12 inches) and 100 years, the average yearly increase in merchantable contents is 9.28 board feet per tree.

Relation between diameter, total height, merchantable length, crown length, and clear length.—(See fig. 9.) In trees from 15 to 30 inches in diameter the merchantable length increases quite regularly as the diameter becomes larger, but in trees above 30 inches the length of

merchantable timber increases but slightly. In proportion to the total height the greatest merchantable length is obtained from trees about 20 inches in diameter, and, as with the Shortleaf, this amounts to only one-half the total height of the tree. The merchantable length is less than the clear length in trees below 20 inches in diameter, but in large trees the reverse is true.

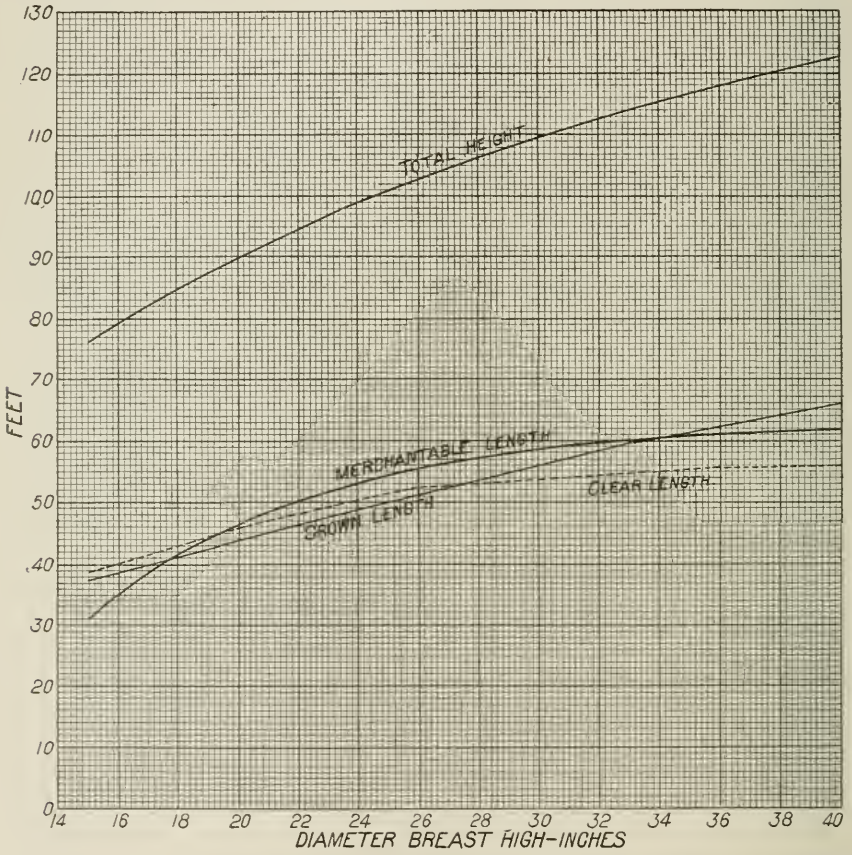

FIG. 9.—Diagram showing the relation between the total height, merchantable length, crown length, and clear length for Loblolly Pine on the basis of diameter breasthigh.

PRACTICAL VALUE OF THE LOBLOLLY PINE AS COMPARED WITH THE SHORTLEAF PINE.

In case conservative lumbering is undertaken upon the tract of the Sawyer & Austin Lumber Company, it will be possible to increase the percentage of the most valuable species in the forest of the future. As already said, there is no doubt whatever that an increase in the stand of pine and a decrease in that of hardwoods would very materially increase the value of the forest. More than this, there are notable differences between the two species of pine, and such differences should also be taken into consideration, and the species which gives promise

of affording the largest returns in the future should be favored in every way possible.

The only advantage which the Shortleaf possesses over the Loblolly Pine is that at the present time Shortleaf Pine lumber commands a slightly higher price than Loblolly, owing principally to the greater amount of sapwood in the Loblolly. On the other hand, the Loblolly has the following great advantages over the Shortleaf:

(1) The reproduction is easier to obtain, because Loblolly endures more shade during extreme youth and so has a better chance in the struggle with the hardwoods.

(2) The rate of growth of Loblolly is much more rapid than that of Shortleaf; hence it produces a given amount of timber in a much shorter time.

(3) Wherever Loblolly becomes firmly established the forest growth tends to be more dense and more nearly a pure pine forest than with Shortleaf. The stand per acre is therefore greater.

These advantages of the Loblolly outweigh the slight superiority in the wood of the Shortleaf, and it would be advisable, therefore, to favor the former species in every possible way. This can be done by using care in the selection of trees to be left standing for seed purposes. Wherever feasible, Loblolly should be left in preference to Shortleaf. Great care is necessary, however, in selecting the trees to be left, as much depends upon the nature of the locality. In some situations the Shortleaf would develop to much better advantage than the Loblolly. In such cases Loblolly should not be favored.

Cow Oak (*Quercus michauxii* Nutt.).

Situation.—This species occurs only in the hardwood bottom type. In these bottom lands the important point is whether the various species occupy the lower or the higher levels, the moist or wet, or the relatively dryer soils. Cow Oak always occurs on the slight elevations and invariably shuns the depressions, showing that it is not suited to an excess of moisture in the soil.

Soil.—No variation exists in the composition of the soil of these bottom lands, and all the species flourish alike on the deep, fresh or moist compact loam.

Tolerance and reproduction.—In common with the other oaks, the Cow Oak is very intolerant of shade and requires full light for development during its entire life. Reproduction of this species is exceedingly scanty, and not likely to be increased by lumbering, for in spite of the favorable conditions of light which would be created it is improbable that the seedlings could withstand the dense growth of cane and the frequent floods.

Occurrence.—Cow Oak is one of the most common as well as the most valuable species of the bottoms, and occurs by single trees evenly

distributed throughout the type. Very few young trees are present; almost the entire stand is composed of veterans.

Development.—The Cow Oaks of these bottoms have massive cylindrical boles, rising 60 or 70 feet before branching. They bulge out considerably at the base, and as a rule incline to be squarish or angular in form. Small clumps of twigs commonly sprout out at short intervals over the whole length of the stem.

The crown is large and massive, consisting generally of two or three heavy main forks, and extends slightly above the surrounding forest canopy, occupying a large amount of space when well developed. It must always have plenty of light and room.

White Oak (*Quercus alba* Linn.).

The White Oaks of the bottom lands are similar in every way to the Cow Oaks described above. When growing on the pine lands this species is inferior in character and of much smaller proportions. It seeks out the best soils, reproduces readily, and is intolerant of shade.

Sweet Gum (*Liquidambar styraciflua* Linn).

Situation.—This species occurs both on the elevations and in the depressions of the bottom lands, and is able to grow in places where standing water is present during most of the year. It is also common throughout the pine lands, but the growth is here very scrubby in comparison with the splendid development attained in the bottoms.

Tolerance and reproduction.—Sweet Gum can tolerate a good deal of shade, and the reproduction grows well under the shelter of oak, ash, hickory, etc. It seems also to flourish equally well in the open. This is the only species of the bottoms with a fair amount of young growth present. Its reproduction occurs everywhere, although in a thin and scattered form.

Occurrence.—Sweet Gum occurs by single trees; occasionally also a pure pole forest of limited extent is met with.

Development.—The bole is inclined to be somewhat crooked and enlarged at the butt, and is fairly cylindrical and free from branches for 50 or 60 feet from the ground. The crown is large and somewhat more dense than that of the Cow Oak.

White Ash (*Fraxinus americana* Linn.).

Situation.—Like the Sweet Gum, the White Ash flourishes in the hollows of the bottoms where water collects, seeming to prefer such locations to the drier elevations; it is found even in the sloughs, where water is almost always present, at least to the depth of a few inches. White Ash occurs to a very limited extent on the pine lands.

Tolerance and reproduction.—White Ash can succeed under a good deal of shade, but young growth is very scarce.

Occurrence.—Always by single trees.

Development.—The bole is massive and cylindrical, and the crown large, spreading, and irregular in shape. It attains about the same proportions as the Sweet Gum.

SHAGBARK HICKORY (*Hicoria ovata* Britton).

Situation.—This species prefers the higher levels in the bottom lands, and is never found in standing water. It occurs also on the pine lands, but its development here is very poor in comparison with the fine proportions it reaches in the bottoms.

Tolerance and reproduction.—Young growth is very scarce; what there is seems to tolerate a certain amount of shade.

Occurrence.—Always by single trees.

Development.—The crown is large and dome shaped, and the bole long, slender, and somewhat tapering; a clear length of 40 to 50 feet is quite common.

HOLLY (*Ilex opaca* Ait.).

Situation.—The Holly seems to be at home alike on the slight elevations and in the depressions of the bottoms, although always shunning any considerable amount of standing water. It occurs but rarely on the pine lands.

Tolerance and reproduction.—This species is very tolerant of shade. It will come up under dense foliage and very slowly force its way through the crowns of all species overtopping it. The reproduction is scattering throughout.

Occurrence.—Always by single trees.

Development.—The Holly is small in comparison with the other species, seldom attaining a height of over 30 or 40 feet or a diameter of over 24 inches. Its bole is tapering and covered almost to the ground by its dense, conical-shaped crown.

HORNBEAM (*Carpinus caroliniana* Walt.).

With the Holly, this species forms a kind of underwood to the large oaks, gums, etc., although it is generally so stunted as to resemble a bush rather than a tree. In regard to situation, tolerance, and occurrence it resembles the Holly, but in mode of growth it is very irregular, usually forming a crooked, short bole and a very broken and open crown.

PART II.

FOREST MANAGEMENT.

INTRODUCTION.

Under ordinary lumbering the forest is treated as if its value lay only in the merchantable timber which it contains. Under practical forestry immature trees have a value because they form the basis for future crops. Practical forestry, through a slight expense in the care of young growth and in the protection of the forest from fire, insures the production of a permanent supply of timber. Ordinary lumbering in saving this expense sacrifices largely or wholly the productive capacity of the lumbered area.

The advantage of practical forestry as a business investment depends naturally upon whether it offers better returns than those to be had from ordinary lumbering. Since practical forestry reduces present profits slightly, in order that the forest may produce a steady supply of timber, its financial success rests upon the safety and value of the future crops which it fosters. For example, uncontrollable danger of fire makes forestry unadvisable, since the care given to the production of a second crop may be nullified by injury to the young forest. Again, a low profit on lumbering may render the probable value of future crops of timber insufficient to justify the attempt to foster them.

The tract of the Sawyer & Austin Lumber Company presents conditions which render the application of practical forestry a thoroughly sound business measure. The forest contains an excellent stand of merchantable timber which can be lumbered inexpensively and for which there is a steady and profitable market. The protection of the forest from fire is practicable at small cost and will render the reproduction of the pine a simple and certain matter. The stand of immature trees of certain sizes is somewhat deficient as the result of forest fires in the past. This deficiency, however, is not large enough to impair future yields seriously, and will be largely remedied under conservative management.

TIMBER YIELDS.

The following table shows, approximately, the present stand of merchantable timber per acre upon the tract of the Sawyer & Austin Lumber Company and the future yields to be expected from the lumbered areas. The measurements of the stand and of its rate of growth

upon which this table is based, were carefully made, and it is believed the table is a fair estimate of what may be expected. It is exceedingly probable that it underestimates rather than overestimates, since not only were the most conservative figures used throughout, but no allowance has been made for the improved conditions for forest growth which will result under the application of conservative lumbering.

The table also shows the yield per acre of merchantable pine which may be expected after twenty, thirty, and forty years, cutting to the diameter limits of 12, 14, 16, 18, and 20 inches breasthigh, and also the time required before a yield equal to the present merchantable stand may again be obtained.

TABLE No. 12.—*Present and future yields of pine per acre, and time necessary before the present yield may again be obtained.*

Cutting-limit, diameter breasthigh.	Present cut.	Cut after 20 years.	Cut after 30 years.	Cut after 40 years.	Present cut again obtained.
Inches.	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*	*Years.*
12	6,067	1,047	2,467	5,270	42
14	5,845	957	2,408	5,278	41
16	5,597	1,225	2,678	5,212	41
18	5,130	1,309	2,612	4,678	42
20	4,561	1,381	2,333	4,174	42

It will be noticed that in general the cut after twenty years increases as the diameter limit is raised; that at thirty years the cut increases to the 16-inch limit, and then falls away again, and that at forty years it decreases as the diameter limit increases.

The time required before equal cuts can again be obtained is irregular and needs explanation. Ordinarily, raising the diameter limit decreases the time. But the table shows that the time is here the same whether the diameter limit is 12 or 20 inches—forty-two years in each case. This is due partly to the fact that the growth of the pine of small diameters, especially that of the Loblolly, is very rapid. In forty-two years Loblolly, with a present diameter of 12 inches, and Shortleaf, with a present diameter of 14 inches, will have passed the 20-inch limit, and Loblolly of 2 inches and Shortleaf of 5 inches will have passed the 12-inch limit. A second reason for the disproportionate length of the period required to produce a second crop equal to the first at a 20-inch diameter limit is the fact that the forest is "abnormal," the number of trees between 14 and 20 inches being especially small, as is shown by fig. 1, the probable result of the severer fires due to the accumulated rubbish when fires first became frequent. These are just the trees which would have to furnish the next equal crop cutting to a diameter limit of 20 inches.

EFFECT OF FIRE PROTECTION UPON FUTURE YIELDS.

An important conclusion follows. The fires which have repeatedly swept the tract have reduced the proportion of pine trees under 22 inches now standing. If the forest were normal—that is, if all age classes were present in sufficient amounts to maintain the present stand of mature timber in years to come—equal cuts could be obtained in much shorter periods than are now necessary, and probably twenty-five years would produce a second crop equal to the first. In that case a total area of 170,000 acres would suffice for a sustained yield equal to the present annual consumption instead of the much larger area now required.

SUSTAINED ANNUAL YIELD OF THE FOREST.

The sustained annual yield which can be obtained from the forest is given in the following table. It shows the annual merchantable cut of pine per acre, the area to be lumbered annually, the total annual cut, and the time required for a second cut equal to the first, for the diameter limits of 12, 14, 16, 18, and 20 inches.

TABLE No. 13.—*Sustained annual yield of merchantable pine in board feet, area to be lumbered annually, and time required to cut over tract.*

Cutting limit, diameter breasthigh.	Area to be lumbered annually.	Annual cut per acre.	Total annual cut.	Time required to cut over tract.
Inches.	*Acres.*	*Board feet.*	*Board feet.*	*Years.*
12	2,380	6,067	14,439,460	42
14	2,439	5,845	14,255,955	41
16	2,439	5,597	13,651,083	41
18	2,380	5,130	12,209,400	42
20	2,380	4,561	10,855,180	42

SUSTAINED ANNUAL YIELD IN RELATION TO THE PRESENT CAPACITY OF THE MILL.

The Sawyer & Austin Lumber Company own and operate a mill with an annual capacity of 40,000,000 board feet. The present tract of 100,000 acres, cutting to a diameter limit of 12 inches, can supply continuously about 14,500,000 feet per year. The following table shows, approximately, the forest area which would be necessary to produce a sustained annual yield of 40,000,000 board feet per year. It estimates for the several diameter limits the annual cut per acre, the area to be lumbered annually, the time required to cut over the present tract, and that required for a second cut equal to the first.

TABLE No. 14.—*Area necessary for a sustained annual yield of 40,000,000 feet per annum.*

Cutting limit, diameter breasthigh.	Annual cut per acre.	Area to be lumbered annually.	Time required to cut over present tract.	Time required before second cut equal to first can be obtained.	Total area necessary for sustained annual yield.
Inches.	*Board feet.*	*Acres.*	*Years.*	*Years.*	*Acres.*
12	6,067	6,593	15	42	276,906
14	5,845	6,844	14½	41	280,604
16	5,597	7,147	14	41	293,027
18	5,130	7,797	13	42	327,474
20	4,561	8,770	11½	42	368,340

Cutting to 12 inches, therefore, a sustained annual yield equal to the capacity of the mill can be obtained by the addition of about 170,000 acres of forest land similar in character to that of the present tract.

INTEREST RETURNS ON CUT-OVER LANDS.

It is obvious that calculations of future financial returns from conservative lumbering can not be infallible, because changes in the value of land or of timber may entirely alter the premises upon which these calculations are based. However, when compiled from adequate and conservative data, estimates of future money returns are of reasonable safety and of no small practical value.

The table below relates simply to land which has been cut over, and shows the annual interest, represented by future cuts, on the capital invested in the land. At the present time cut-over lands can be bought at an average price of 50 cents per acre, but, in order to be conservative, calculations are made with such lands valued at $1 and $1.50. Taxes are taken at 3 cents per acre per annum, and the cost of protection against fire at 2 cents per acre per annum, making a yearly expense of 5 cents per acre per annum. Pine stumpage is now worth $1.50 per thousand board feet, and the returns from future cuts were accordingly figured for stumpage values of $1.50 and $2. As a matter of fact, the probability is that after thirty or forty years the value of pine stumpage will be considerably above $2 and the interest returns shown by future cuts greatly increased in consequence.

TABLE No. 15.—*Annual interest represented by future cuts on the capital invested in cut-over lands.*

STUMPAGE VALUE, $1.50 PER THOUSAND BOARD FEET.

Cutting limit, diameter breast-high.	After 20 years.		After 30 years.		After 40 years.		When equal cut occurs.		Equal cut again obtained.
	$1 per acre.	$1.50 per acre.	$1 per acre.	$1.50 per acre.	$1 per acre.	$1.50 per acre.	$1 per acre.	$1.50 per acre.	
Inches.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Years.*
12	3.9	3.1	4.9	4.1	6.6	5.6	7.0	6.0	42
14	3.6	2.9	4.8	4.0	6.6	5.7	7.0	6.0	41
16	4.6	3.7	5.4	4.5	6.5	5.6	6.7	5.8	41
18	4.9	3.9	5.2	4.4	5.8	5.0	5.9	5.1	42
20	5.2	4.1	4.7	3.9	5.2	4.5	5.3	4.5	42

STUMPAGE VALUE, $2 PER THOUSAND BOARD FEET.

12	5.2	4.2	6.6	5.5	8.8	7.5	9.3	8.0	42
14	4.8	3.8	6.4	5.4	8.8	7.5	9.3	8.0	41
16	6.1	4.9	7.1	6.0	8.7	7.4	9.0	7.7	41
18	6.5	5.2	7.0	5.8	7.8	6.7	7.9	6.8	42
20	6.9	5.5	6.2	5.2	7.0	6.0	7.0	6.0	42

CONCLUSIONS.

The study made by the Bureau of Forestry establishes the fact that the application of practical forestry to the tract of the Sawyer & Austin Lumber Company would be a sound business measure. It shows furthermore that in the cheapness of logging, the value of the product, the quick growth and the ready reproduction of the timber trees, and the practicability of inexpensive and effective measures against fire, the opportunity is a markedly favorable one.

The yield to be expected from cut-over lands shows a high return from the capital invested in them. Cutting to the advised diameter limit of 12 inches breasthigh, or about 14 inches on the stump, with stumpage reckoned at $2 per 1,000 board feet, and the value of cut-over land at $1 per acre, the average annual interest represented by the future crop on cut-over lands is, for a period of forty years, nearly 9 per cent. In other words, after the Sawyer & Austin Lumber Company have lumbered their present tract at the rate of 14,500,000 feet per year, the lands which have been cut over will be producing timber which, at a conservative estimate, represents an income of 8.8 per cent on the capital invested in them.

It has been shown that, in order to assure a sustained annual yield equal to the capacity of the mill, the addition of 170,000 acres to the present tract is necessary. With this addition, or its equivalent in stumpage, the Sawyer & Austin Lumber Company can cut continuously 40,000,000 board feet per year. If this addition is not made, it is clearly unadvisable for the company to lumber its tract upon the principle of a sustained annual yield, since this would fall short by about 25,500,000 board feet of the annual capacity of its mill.

FIG. 1.—PINE TOPS AFTER A GROUND FIRE.

FIG. 2.—THE STEAM SKIDDER.

The quantity of timber taken annually from the tract has no bearing upon the main question before the company: Whether the application of conservative lumbering is justified by the value reasonably to be expected for a future crop of timber from the lumbered area. Under the very small added expense incident to the application of the rules for forest management which follow, the productive capacity of the cut-over lands will be preserved and they will supply a second crop of merchantable timber, which represents an exceedingly good rate of interest upon the capital invested in them. Whether the second crop is grown in order to be cut by the Sawyer & Austin Lumber Company, or whether the cut-over lands be sold after the merchantable stand is removed, has no bearing upon the advisability of conservative lumbering in the present case. The increased value of the cut-over lands in either event renders the application of practical forestry in the lumbering now going on a safe and advantageous business measure.

RULES OF MANAGEMENT.

CUTTING LIMIT FOR PINE.

The cutting limit for pine should be placed at 14 inches on the stump (12 inches breasthigh). This is advisable for the following reasons:

(1) The largest cut at the present time will be obtained.

(2) An equal cut can be harvested after the same number of years required in case a higher cutting limit were used.

(3) As a result, a sustained annual yield equal to the capacity of the mill can be obtained by the addition of a much smaller forest area than that required by a higher diameter limit.

(4) With a cutting limit of 12 inches, logging operations will be more concentrated and hence more profitable than if the limit were higher.

(5) A cutting limit below 12 inches would be inadvisable both financially and silviculturally.

SEED TREES.

When the first cutting is made a small number of Loblolly and Shortleaf Pine trees above 12 inches in diameter breasthigh should be left standing. These trees should be selected and marked beforehand by a trained forester. The Bureau of Forestry cooperates with the Sawyer & Austin Lumber Company in these markings. It is probable that after they have once been well started by an agent of the Bureau, and a competent man in the employ of the company has had opportunity to become thoroughly acquainted with the manner in which they are made, they can be carried out successfully thereafter under his supervision alone. The number of trees to be left should be determined by the nature of the locality. In all cases the Loblolly is to be favored, unless the locality be distinctly unfavorable to this species. The leaving of such trees for seed purposes will not involve any appreciable loss to the company.

CUTTING LIMIT FOR THE HARDWOODS OF THE BOTTOM LANDS.

In the hardwood bottoms the cutting limit should be placed at 20 inches. Although no study of the rate of growth in these bottoms was made, it seems probable from the composition of the stand that if such a cutting limit be adopted a second cut can be obtained when the pine lands are lumbered again.

Every opportunity should be taken advantage of to cut and utilize the hardwoods of the pine lands, even at a very small profit.

HEIGHT OF STUMPS.

Stumps should not be cut higher than 18 inches, and all trees below 18 inches on the stump should be cut 12 inches from the ground.

At the present time stumps are being cut at an average height of 18 inches from the ground, and this rule appears to be fairly satisfactory. No trees below 18 inches in diameter on the stump are now cut, but probably no difficulty would be met with in getting the sawyers to cut the small trees (below 18 inches) at 12 inches from the ground.

Logs should also be cut as high up into the crowns as conditions will allow.

PROTECTION AGAINST FIRE.

The principal difficulty in the way of adopting a good system of fire protection is the broken character of the company's holdings. If the tract were in one solid block the matter would be much simplified. Cut up as it is at present by farms and private wood lots, the sources of danger from fire are greatly multiplied, because fires purposely set on these holdings are never watched or controlled, and as a general thing quickly spread.

The forest would prosper most if the whole tract could be protected from fire. On account of the difficulties just mentioned, however, such a course would in all probability be impracticable at the present time. The most urgent need at present is a thorough system of protection for the cut-over lands. This is entirely practicable and should by all means be adopted. After the opening of the forest the young growth will quickly develop on these lumbered areas, and it is of the greatest importance that it be given every possible chance for rapid growth and that the reproduction of the pine be effectively protected in every way. The tops of felled trees are a source of great danger and should be burned as soon as they are dry enough to burn readily, at a time when the forest floor is damp and there is no danger of the fire spreading. It is probable that the cheapest and most effective way of disposing of the tops will be to skid them into piles and then to burn as many together as can conveniently be skidded to one point.

Fire protection would cost about $500 per year for the first few years. This would pay the salary of one man, who should have entire charge of burning the tops and at the same time act as a fire guard

and patrol the cut-over land. By such a system the area under fire protection would increase from year to year, until finally protection would be extended to the whole tract. As soon as the lumbered area becomes too large for one guard to control, another man should be added. In case a fire breaks out which the guard can not control by himself, he should have authority to hire what help may be necessary, and, if such a fire occurs in the vicinity of lumbering operations, the logging force should be turned out to fight it.

Roads are excellent fire lines, and form very good bases from which to work against fire, as well as checking any light ground fire in whose course they lie. The abandoned railroad spurs are valuable for the same purpose, and should be kept clear of all litter. If this is done the damage from fire will be very materially decreased.

Great care should be taken to keep in good order the spark arresters of the locomotives and skidder.

The main point to be urged is a thorough system of fire protection for the cut-over lands. At the present rate of cutting some 6,500 acres will be lumbered annually. If a start is now made by protecting the area cut over during the past year, the initial expense will be small, and, if the attempt proves successful, another 6,500 acres can be added the next year, and the protected area thus gradually increased. It is reasonable to expect that as time goes on experience will tend toward a reduction in expenses, and also that as the sentiment of the inhabitants improves, forest fires will become less numerous.

CARE IN FELLING.

It is fully realized that it is almost impossible to secure care in felling the trees, owing to the character of the labor force employed. Moreover, the small amount of young growth already present fortunately makes regulations regarding this of little importance. If the ground were covered by a valuable reproduction of pine and the labor force were of a different type, rules would be required.

INSPECTION.

An agent of the Bureau of Forestry should inspect each year the area lumbered during the preceding year, and at the same time mark the seed trees to be left standing in the next cutting area. He should report fully as to the manner in which the rules for lumbering have been carried out and describe in detail any damage caused by fire in the preceding year. This will involve an expense to the company of about $200 a year.

SUMMARY OF RULES FOR LUMBERING.

(1) The cutting limit for pine to be 14 inches on the stump, and for hardwoods 20 inches.

(2) A certain number of pine trees over 14 inches on the stump to be marked and left standing for seed purposes.

(3) Hardwoods on pine lands to be cut whenever practicable.

(4) All pine 18 inches and over in diameter on the stump to be sawn not higher than 18 inches from the ground, and that below 18 inches in diameter on the stump at 12 inches from the ground.

(5) Care to be used in the felling to do as little damage as practicable to valuable young growth.

LIST OF TREES FOUND.

Shortleaf Pine	*Pinus echinata* Mill.
Loblolly Pine	*Pinus tæda* Linn.
Bald Cypress	*Taxodium distichum* (Linn.) Rich.
Butternut	*Juglans cinerea* Linn.
Black Walnut	*Juglans nigra* Linn.
Bitternut Hickory	*Hicoria minima* (Marsh.) Britton.
Shagbark Hickory	*Hicoria ovata* (Mill.) Britton.
Pignut Hickory	*Hicoria glabra* (Mill.) Britton.
Hornbeam	*Ostrya virginiana* (Mill.) Koch.
Hornbeam	*Carpinus caroliniana* Walt.
Beech	*Fagus atropunicea* (Marsh.) Sudworth
Chinquapin	*Castanea pumila* (Linn.) Mill.
White Oak	*Quercus alba* Linn.
Post Oak	*Quercus minor* (Marsh.) Sargent.
Overcup Oak	*Quercus lyrata* Walt.
Cow Oak	*Quercus michauxii* Nutt.
Red Oak	*Quercus rubra* Linn.
Yellow (or Black) Oak	*Quercus velutina* Lam.
Spanish Oak	*Quercus digitata* (Marsh.) Sudworth.
Black Jack	*Quercus marilandica* Muenchh.
Water Oak	*Quercus nigra* Linn.
Willow Oak	*Quercus phellos* Linn.
White Elm	*Ulmus americana* Linn.
Red Mulberry	*Morus rubra* Linn.
Papaw	*Asimina triloba* (Linn.) Dunal.
Sassafras	*Sassafras sassafras* (Linn.) Karst.
Sweet Gum	*Liquidambar styraciflua* Linn.
Sycamore	*Platanus occidentalis* Linn.
Honey Locust	*Gleditsia triacanthos* Linn.
Locust	*Robinia pseudacacia* Linn.
American Holly	*Ilex opaca* Ait.
Deciduous Holly	*Ilex decidua* Walt.
Silver Maple	*Acer saccharinum* Linn.
Red Maple	*Acer rubrum* Linn.
Boxelder	*Acer negundo* Linn.
Basswood (Linn.)	*Tilia americana* Linn.
Dogwood	*Cornus florida* Linn.
Black Gum	*Nyssa sylvatica* Marsh.
White Ash	*Fraxinus americana* Linn.

○

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF FORESTRY—BULLETIN No. 33.

GIFFORD PINCHOT, Forester.

THE WESTERN HEMLOCK.

BY

EDWARD T. ALLEN,

FIELD ASSISTANT, BUREAU OF FORESTRY.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1902.

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TYPICAL FOREST MIXTURE IN WASHINGTON. SPECIES, FROM LEFT TO RIGHT: RED FIR, SPRUCE, HEMLOCK, CEDAR, RED FIR.

U. S. DEPARTMENT OF AGRICULTURE.

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GIFFORD PINCHOT, Forester.

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FIELD ASSISTANT, BUREAU OF FORESTRY.

WASHINGTON.

GOVERNMENT PRINTING OFFICE.

1902.

LETTER OF TRANSMITTAL

U. S. Department of Agriculture,
Bureau of Forestry,
Washington, D. C., March 8, 1902.

Sir: I have the honor to transmit herewith a report entitled "The Western Hemlock," prepared by Edward T. Allen, field assistant in the Bureau of Forestry, and to recommend its publication as Bulletin No. 33 of this Bureau.

Very respectfully,

Gifford Pinchot,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

SUMMARY.

Western Hemlock has suffered so severely through the reputation of its Eastern relative among lumber manufacturers and consumers that it has at present scarcely any market standing. To remove this prejudice and to introduce the Western Hemlock to the market by pointing out its uses, its economic value, and the conditions under which it may profitably be grown, lumbered, and manufactured, was one of the purposes of a two seasons' study on the ground, the results of which are embodied in this report. The other purpose was to ascertain the qualities and possibilities for forestry of a tree that must inevitably take on great importance in conservative lumbering in the Northwest.

The conclusions to which this study has led may be briefly summarized as follows:

(1) The wood of the Western Hemlock is far superior to that of the Eastern tree. It is suitable for use in all ordinary building work; it furnishes good paper pulp; it is sufficiently light and strong to make excellent woodenware stock, and it is particularly valuable for indoor finishing. Its bark is half again as rich in tannin as that of the Eastern tree.

(2) Under favorable conditions the Western Hemlock reproduces abundantly and grows very rapidly. Since these conditions are usually disadvantageous to Red Fir, hemlock may often be counted upon to reforest cut-over lands when Red Fir would probably fail to establish itself.

(3) The Western Hemlock has now to contend mainly with a prejudice which is based upon a knowledge of the Eastern tree alone. The importance of bringing it into the market on a large scale as a substitute for Spruce and White Pine is growing rapidly. Its qualities entitle it to rank among the valuable timber trees of this continent.

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THE WESTERN HEMLOCK.

INTRODUCTION.

The stimulus apparent in the lumber industry of the Northwest within the last few years, with the recent immense investments in standing timber in that region and the realization that its supply is limited, has created an interest in the long-despised Western Hemlock. This species forms 13 per cent of the forests of Washington and is abundant in many parts of Oregon. Apparent inability to utilize it is one of the most serious factors in the local lumber problem. Were it practicable for the Hemlock to stand unharmed until it became established in the market there would be less cause for immediate concern. But, seldom growing in pure stands, the Hemlock in mixture with the Red Fir, Spruce, and Cedar now being logged is left standing by the lumberman to be destoyed by fire, wind, or insects, a complete loss to the owner and to the community.

This waste is in line with the history of lumbering in the Northeastern and Lake States, but with more serious result and with less justification. The Eastern Hemlock is an inferior wood, and therefore was left uncut until more valuable species became scarce. The disadvantage of the Western Hemlock has been not its quality, but its confusion with the Eastern species. It has been condemned without trial except by a few, who, realizing the difficulty of convincing the market, have manufactured under the names of Fir, Spruce, or Alaska Pine as much Hemlock as they dared without fear of detection.

The importance of bringing Hemlock into the market on a large scale is now being realized and its surreptitious use is somewhat greater than it was formerly. There is still, however, a total lack of organized effort, and practically nothing is done to acquaint the consumer with its merits.

DISTRIBUTION.

The Western Hemlock extends from Alaska southward to Marin County, Cal., to the coast region in California and southern Oregon in the southern, and east to Montana in the northern, portion of the belt. The first printed mention of the species occurs in an account of the voyage of Admiral Vancouver, a British navigator, who visited Puget Sound in May, 1792. In July of the following year Alexander Mac-

kenzie, the first white man to cross the North American continent, saw the Hemlock in latitude 52° on the coast of what is now British Columbia. The first description of the tree was published in 1814 in the journal of the Lewis and Clarke Expedition, which passed the winter of 1805 near the mouth of the Columbia River. These explorers spoke of it as a tree "four to six feet in diameter, straight, round, and regularly tapering."

The distribution of the species indicates clearly its chief requirements to be a cool and moist climate. Western Washington and Oregon, where it reaches its best development, are divided into three longitudinal belts, each with distinct characteristics of soil and climate. The western strip, between the Pacific Ocean and the Coast Range (which becomes the Olympic Mountains in the north), has a fertile, usually clayey soil and an annual rainfall of from 70 to 100 inches. This strip contains a large proportion of Hemlock, in mixture with Spruce, Cedar, and Red Fir. (See Frontispiece.) Between the Coast Range and the foot of the Cascades lies a belt which, protected from the moist sea winds, is comparatively dry. In Washington the soil is glacial drift, consisting chiefly of gravels; in Oregon it forms the rich agricultural lands along the Willamette and other rivers. In this belt there is little Hemlock, the growth being nearly pure Red Fir, with Cedar on the low ground, and some Pine. On ascending the west slopes of the Cascades the change is again distinctly marked. The soil is of either volcanic or sedimentary origin, and the increasing altitude causes condensation of the moisture which escapes the Coast Range and is carried eastward over the central valley. Here the Hemlock again appears and, at an altitude of from 1,500 to 3,500 feet, reaches its best development, and is most free from insect attacks and from disease.

ASSOCIATED SPECIES.

Hemlock rarely occurs in pure stands of great extent, although Clallam County, Wash., contains large forests of Hemlock, and there are tracts in Jefferson and King counties in which the percentage of other species is small. (Pl. I.) It commonly occurs in a mixture in which Red Fir is apt to be the prevailing species. (Pl. II.) Along the coast it is associated with Spruce and Cedar, and in northern California with Redwood. Occurring up to an altitude of nearly 5,000 feet, it is almost always one of the many species which form the widely varying mixture on the west slope of the Cascades. With Red Fir, Spruce, Cedar, and White Fir, it constitutes the forest now being lumbered in the foothills; higher, its associates are White Pine (Pl. III, fig. 2), Noble Fir, Amabilis Fir (Pl. III, fig. 1), and, near its upper limit, Alaska Cedar and the Alpine Hemlock. Toward the west slope of the Rockies, the eastern limit of its range, it becomes more distinctly a mountain tree and grows in what has been called the White Pine

FIG. 1.—PURE STAND OF WESTERN HEMLOCK, CASCADE FOOTHILLS, WASHINGTON. ALTITUDE, 1,300 FEET.

FIG 2.—PURE STAND OF WESTERN HEMLOCK, CASCADE FOOTHILLS, WASHINGTON. ALTITUDE, 1,300 FEET.

TYPICAL MIXTURE OF RED FIR AND HEMLOCK, BLACK HILLS, WASHINGTON.

FIG. 1.—SEMI-ALPINE FOREST OF NOBLE FIR, RED FIR, AND WESTERN HEMLOCK, MOUNT RAINIER FOREST RESERVE. ALTITUDE, 2,400 FEET.

FIG. 2.—WESTERN WHITE PINE, CASCADE MOUNTAINS, WASHINGTON. ALTITUDE, 2,500 FEET.

zone. Other trees in this zone are Tamarack, Engelmann Spruce, Lodgepole Pine, and Cedar. Throughout the range of the Western Hemlock broadleaf trees are so few that they are of no consequence as factors in the mixture. Where the climate is too dry to be generally favorable, Hemlock takes refuge on north slopes and in shaded valleys, where it can hold its own against Fir mainly because, since fire is infrequent, the latter finds an unsuitable seed bed and insufficient light in such localities.

A list of the trees of Oregon and Washington contains a few which seldom or never occur in mixture with Hemlock, but it is given for reference on page 54.

UNDERGROWTH.

Since Hemlock rarely forms a pure stand it has no characteristic undergrowth of its own. Vine Maple is common and Oregon Grape, ferns, and mosses constitute the smaller growth. In low, wet situations Devil's Club and Salmonberry are often abundant. No shrub is more characteristic of the pure fir forest than Salal, which prefers a dry soil and is therefore not much in evidence in the moist localities where Hemlock is at its best. Where it occurs forest reproduction is poor, for Salal covers the ground with a dense thicket 2 or 3 feet high. The leaves are thick and oily and encourage rather than prevent fire. A list of some of the more important shrubs which occur in the forests of Washington and Oregon, will be found on page 55.

HABIT.

The Western Hemlock has been found with a diameter of 8 and a height of 250 feet, and these dimensions may occasionally be surpassed. As a rule mature trees are from 3 to 5 feet in diameter at breastheight. The trunk is exceedingly cylindrical, although often with a sudden, irregular buttressing near the base, due to the germination of the seed on a log or stump. The branches are small and pendulous, forming a narrow spire-shaped crown which offers little resistance to the wind and serves somewhat to offset the insecurity of a shallow root system. Near the top of the tree and where exposed to the light the foliage is exceedingly dense and tufted, appearing almost fascicled, a provision which secures a very large leaf surface. Overtopped trees are able to form spreading crowns, and thus to accomplish the same result. The Hemlock clears itself of branches somewhat slowly.

TOLERANCE.

Western Hemlock will germinate and grow under dense shade. This characteristic, called tolerance, is one of the most important factors in determining the composition of the forest. Red Fir requires abundant light in youth, and hence seedlings of this species do not

come up beneath a heavy stand of mature timber. Hemlock and Cedar thrive under cover and, where climate and soil are favorable, occur in stands containing trees differing widely in age, since young trees are continually growing up to replace those which die and are blown down. In a forest of Red Fir, however, the trees are practically of the same age and no reproduction takes place until a large proportion of them are removed and light is freely admitted to the ground. This is usually accomplished by fire.

Where, as is frequent, the forest consists of an upper story of large Fir and a lower story of Hemlock of varying age, it often occurs that

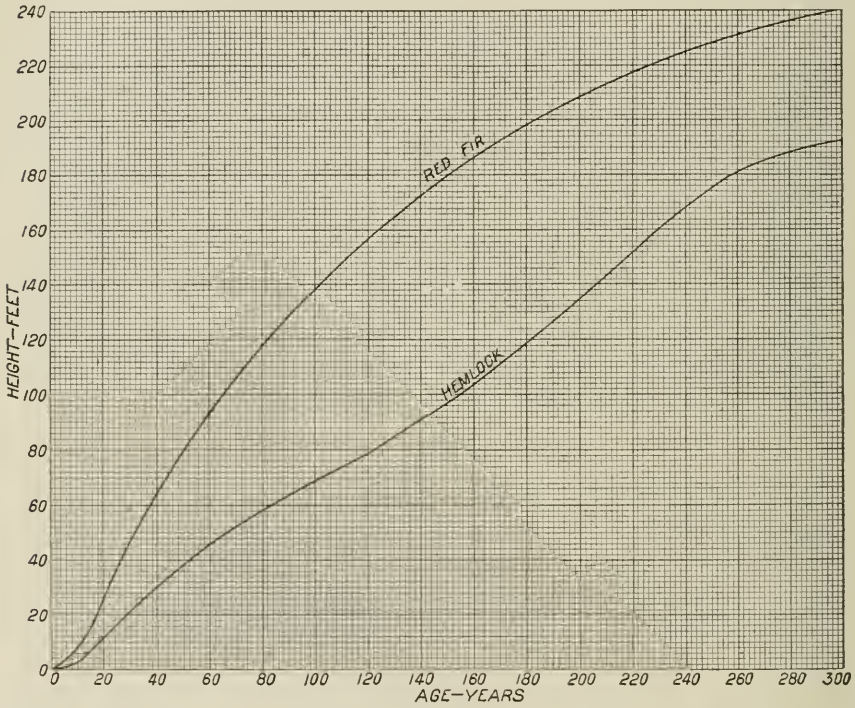

FIG. 1.—Diagram showing height growth of mature Red Fir and of Hemlock growing beneath it, calculated on a basis of age.

as the Fir dies the Hemlock gradually takes its place. Where Fir is killed out by conk or ground-rot, the process is often rapid; and examination shows that the small areas stocked with a pure growth of young Hemlock, so often seen in the midst of a Fir forest, were often caused by this means. It is probable that disease in the old Red Fir forests is largely responsible for the present distribution of Hemlock in Washington and Oregon.

GROWTH UNDER COVER.

No tree grows as rapidly in the shade as it does in the light, and Hemlock which has come in under Fir shows a close and often very

irregular grain. The rate of growth often quickens as the tree pushes up toward the light, and the grain becomes coarser and the wood lighter. Red Fir, on the other hand, or Hemlock which has enjoyed light in youth, shows a rapid growth near the heart and a slow growth near the bark, when age has diminished the rate.

A peculiar silvicultural problem is presented by the constantly diminishing density of the Red Fir overwood. Nearly all Red Fir forests start on burns or open land and are very dense for the first fifty or one hundred years. The young Hemlock which starts beneath the Fir during this period gets little light and grows slowly. Later, as

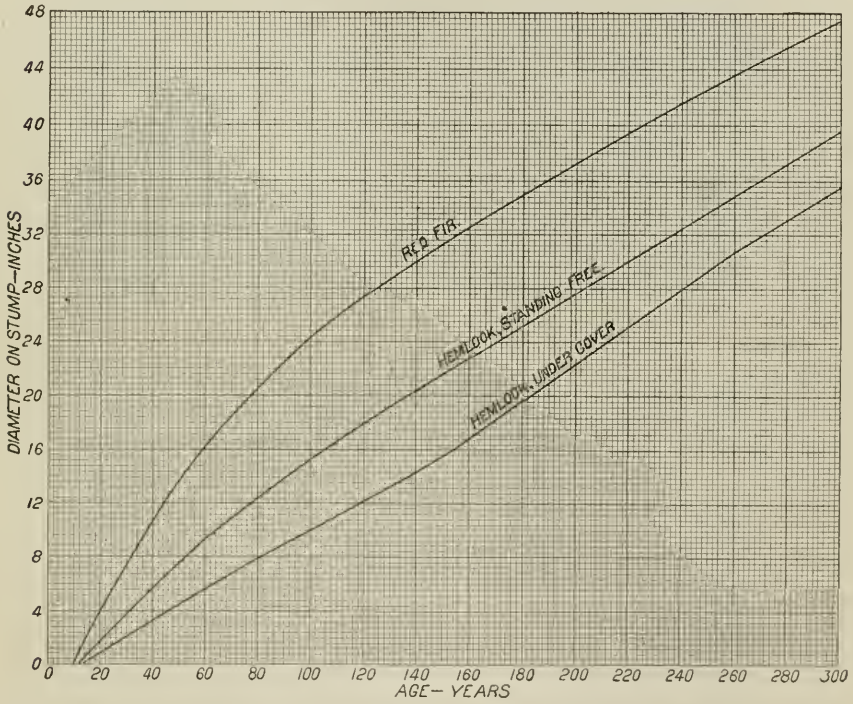

FIG. 2.—Diagram showing diameter growth of mature Red Fir and of Hemlock, calculated on a basis of age.

the Firs begin to crowd each other out, more light is admitted and the lower story of Hemlock grows more rapidly. Hence, the older the overwood the faster grow the Hemlock seedlings which come in beneath it. The culmination of height growth as the Hemlock approaches maturity therefore differs greatly from that under the usual forest conditions where the supply of light remains constant. Instead of falling off normally, as the trees approach maturity the growth of the Hemlock forming the lower story is constantly stimulated by the diminishing density of the upper story of Red Fir. (Figs. 1, 2.)

DEMANDS UPON SOIL AND MOISTURE.

The Hemlock ranges from mucky swamps to rocky hillsides. It requires, however, a heavy rainfall and is seldom found where the precipitation averages less than 40 inches annually, reaching best development where it is above 70 inches. The finest Hemlock in Washington grows at an altitude of 2,000 to 3,500 feet on the western foothills of Mount Rainier, where the annual precipitation is seldom less than 80 inches and snow lies half the year.

REPRODUCTION.

A prolific seeder and not fastidious as to seedbed, Hemlock reproduces freely under a wide range of conditions. In the drier inland regions, or where the soil has been severely burned, it does not rival Red Fir, but on the coast it far excels it. While Fir prefers a bare mineral soil, Hemlock reproduces better on a humus of leaves or rotten wood. (Pls. IV, V.) Stumps and fallen logs form a favorite seedbed, and large trees are often seen standing on leg-like roots, which, starting from the log or stump, have extended downward to the ground, finally to be left unsupported by the decay of their host. (Pl. IV, fig. 1.) Hemlock is thus enabled often to seed up ground where there is sufficient light for the germination of Fir. Insects, wind, or a ground fire may cause a tangle of fallen timber, later covering the ground with rotten wood. A few fires may start under such conditions, but Hemlock is likely to get the mastery. Near South Bend, Wash., is an illustration of this on a large scale. About sixty years ago the standing timber on a tract covering nearly a township was destroyed. No sign of fire is visible. Appearances indicate that this destruction was wrought by the measuring worm, which has since attacked large areas of Hemlock along the coast, notably near Grays Harbor and in Oregon. The original stand was chiefly Hemlock and Spruce; now, almost rotten, it covers the ground 1 to 2 feet deep. A few seed trees survive the catastrophe and record its date clearly by two or three very close rings, showing slow recovery from the injury, followed by greatly accelerated growth due to the increased light. Although there was an abundant supply of Red Fir seed, none germinated, and 90 per cent of the young growth now standing is Hemlock, with an occasional Spruce or Cedar. The Hemlock is of very rapid growth, averaging over 100 feet high and 13 inches in diameter at 55 years of age.

Hemlock bears seed almost every year. The age at which seed bearing begins varies with the amount of light in which the tree has grown. Trees coming up in burns may bear when 25 or 30 years old, but those which have grown in the woods do not bear until much later. The seeds, like those of most conifers, are winged and may be carried great distances by the wind.

FIG. 1.—YOUNG HEMLOCK GROWING ON RED FIR STUMP.

FIG. 2. HEMLOCK, SECOND GROWTH, 12 TO 14 YEARS OLD, ON LOGGED-OFF LAND, NEAR HOQUIAM, WASH.

FIG. 1.—HEMLOCK SEEDLINGS GROWING ON ROTTEN WOOD.

FIG. 2.—HEMLOCK, SECOND GROWTH, 15 YEARS OLD, ON LOGGED-OFF LAND, NEAR HOQUIAM, WASH.

ENEMIES.

FUNGI (CONK AND GROUND-ROT).

Few Western trees maintain so continual a warfare to preserve existence as does the Hemlock. Its shallow root system is exposed to ground fires and also renders the tree unable to withstand heavy winds. The bark is thin, affording little protection against fire or other injury. The tree is liable in old age to attack by several fungi, notably conk (*Trametes pini* and *Echinodontium tinctorium*) and ground-rot (*Polyporus schweinitzii*). The latter is the more prevalent, and makes long-butting necessary in many localities. Little can be done as yet to prevent these timber diseases, but a better understanding of them may impress upon the lumberman the advisability of utilizing infected timber before it is ruined. Both conk and ground-rot are active, independent enemies of trees, and not, as is often believed, merely followers of disease due to unfavorable conditions.

The "conk" or bracket seen on affected trees is the fruiting organ. On its under side are innumerable minute spores or seeds. (Pl. VI, fig. 1.) These float through the air and lodge upon other trees. Conk spores never enter through the bark, but usually through the scars of broken branches. Once the spore is established, root-like fibers grow inward, destroying the structure of the wood. When sufficient nourishment has been extracted a small conk is produced, which grows by annual layers on its under side, and in turn liberates millions of spores.

Conk spreads rapidly, especially where the trees are badly scarred. Storms aid the disease by breaking many branches. Trees which have grown in an open stand in youth are apt to become conky because the branches are large, and, when they finally die off, they leave wounds which often do not heal over thoroughly. Damp climates and soils are favorable to the growth of conk.

In ground-rot the fruiting organs are on or near the roots. Hence the spread to other trees is usually brought about either by direct infection of interlacing roots or by the carrying of spores in the fur of burrowing animals. Hence ground-rot is apt to spread more slowly than conk and to be confined to spots in the forest. On the other hand, since the tender growing ends of roots may be infected without first being scarred, the existence of one diseased tree is almost certain to affect a group. Conk and ground-rot in Red Fir, Hemlock, and Spruce are caused by the same fungi and may be communicated from one species to another.

It is evident, therefore, that the immediate cutting of diseased trees is advisable, not only to save as much timber as possible, but in order to prevent the infection of others. The merchantable stand of many tracts of Red Fir in Washington has been reduced one-third by conk in ten years. It would often be better policy to incur considerable

expense in lumbering conky trees immediately than to cut only the sound timber near at hand.

The occurrence of fungous diseases is quite variable, but probably 20 or 25 per cent of all Hemlock under 3 feet in diameter is affected. Above that diameter the percentage is larger—possibly 50 per cent. Red Fir suffers much less, except in central and southern Oregon, where from 30 to 40 per cent is diseased. These estimates do not mean that so large a portion of the standing timber is actually lost, for often part of a diseased tree can be used, especially in the case of ground-rot, when long-butting constitutes the only loss. (Pl. VIII, fig. 2.)

INSECTS.

Dr. A. D. Hopkins, of the Division of Entomology, U. S. Department of Agriculture, who has charge of the investigation of forest insects, has kindly furnished the following information relating to the insects of the Western Hemlock, mainly quoted from data published by him:

Very little is known of the insect enemies of the Western Hemlock, or of methods of preventing losses from their ravages. During my investigation in the Northwest in the spring of 1899, under authorization from the honorable Secretary of Agriculture and instructions from Dr. L. O. Howard, some observations were made which convinced me that the Western Hemlock has some very destructive insect enemies.

In my preliminary report on the "Insect Enemies of Forests in the Northwest," Bulletin 21, N. S., U. S. Department of Agriculture, the following references are made to some of the insects observed:

On page 8, to an undescribed bark-beetle (*Hylesinus* sp.), which was found at Newport, Oreg., to be quite common in recently felled Hemlock.

On page 9, to a trouble which had caused the death of a large number of Noble Fir and Hemlock in the Cascade Forest Reserve near Berry, Oreg. While I was not able to secure specimens of the insects which doubtless caused the death of these trees owing to the fact that the trees had been dead too long, I concluded from the character of their work on the outer sapwood that it must be a Buprestid, possibly belonging to the genus Melanophila. Many of the wounds made by the insect had healed over before the trees died, thus presenting conclusive evidence that they were attacked while living and probably while in a healthy condition.

In the vicinity of St. Helen, Oreg., investigations were made of a serious trouble affecting the Hemlock and Red Fir, which proved to be similar to, if not identical with, that affecting the Hemlock and Noble Fir in the Cascade Reserve. The work of apparently the same Buprestid larvæ was found in healthy, dead, and dying trees, and I was fortunate in securing a few larvæ; also some nice specimens of healed-over galleries. The latter presented conclusive evidence that the attack had been made on healthy growing trees. It seems that the trees succumb only after several years of successive attack by this insect. The extensive cutting of timber for fuel carried on here does not seem to answer the usual purpose of attracting the insects away from the living trees; therefore this is a problem of considerable interest, and, under more favorable conditions for study, should receive attention in order to determine some methods of preventing the ravages, which may prove to be even more extensive than at present.

FIG. 1.—"CONKY" LIVING HEMLOCK, SHOWING FRUITING ORGANS.

FIG. 2.—DISTORTION OF TRUNK AND BRANCHES OF HEMLOCK, CAUSED BY ARCEUTHOBIUM OCCIDENTALE.

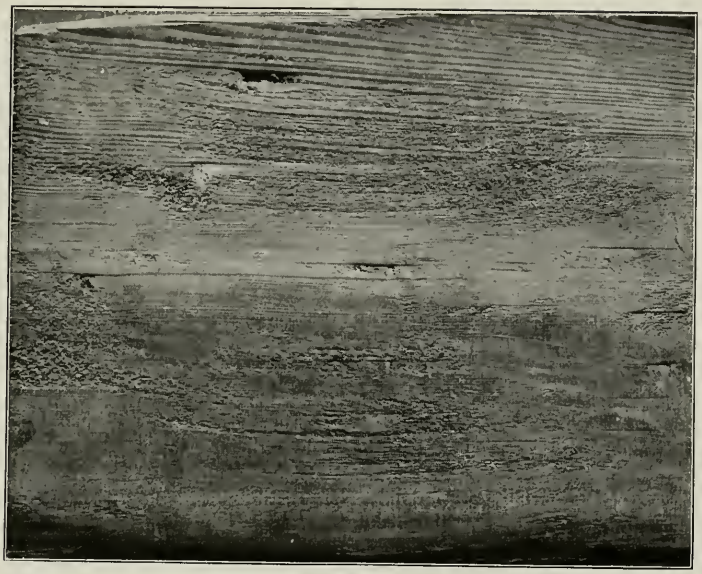

FIG. 1.—"BLACK CHECK" IN HEMLOCK LUMBER, CAUSED BY INSECT INJURY WHEN TREE WAS SMALL.

FIG. 2.—HEMLOCK, NEAR HOQUIAM, WASH., KILLED BY BUPRESTID LARVÆ.

In the vicinity of Ahlers (now Push), Oreg., I found a vast amount of dead Spruce and Hemlock. The trees had been dead eight or nine years, and hence it was not possible to personally investigate the cause of the trouble. I was particularly fortunate, however, in obtaining from the postmaster, Mr. Herman Ahlers, a most interesting account of the beginning and ending of the trouble as observed by him at the time. (Page 10.) The work of this insect has not, I believe, been previously recorded.

Mr. Ahlers says: "The worms commenced to attract a little attention here in 1889. A few moths were seen in the fall of the same year. In July, 1890, the worms appeared in great numbers, the first on the Hemlock, feeding on the base of the leaves and cutting them off. When standing beneath the trees the droppings from the insects and the falling leaves sounded like rain. When all of the leaves were eaten from the trees the worms would let themselves down by means of webs, and if they were not full grown would feed on the leaves of all kinds of shrubs and trees, except the Douglas Spruce and Cedar. The worms were observed during July and August and disappeared in the latter month, probably going into the ground to pupate. In October the moths began to come out. They were grayish white with dark markings on the wings. The wings spread about 1½ inches. The moths would appear on the wing about 3 o'clock in the afternoon in enormous swarms around the tops of the trees, resembling a white cloud. They continued to fly for about three weeks, at the end of which time the ground was covered with the dead insects, and the small streams were filled with them, in some places forming dams. The next year, 1891, they attacked the Sitka Spruce and defoliated the trees, which died the following fall or winter. * * * When the worms were coming down from the trees the webs made the trees look as if they were covered with a grayish veil. The worms were about 1½ inches long, the sides grayish green, with darker gray zigzag markings on the back. When traveling they measured their way. This trouble extended over parts of Clatsop and Tillamook counties, killing all the Hemlock and Sitka Spruce in a belt between elevations of about 450 and 1,200 feet above tide. The Douglas Spruce and Red Cedar were not injured." (Page 18.)

At the time of my visit much of the area covered by dead timber had been frequently burned over by forest fires, so that in some places nearly all of the dead timber had disappeared, but in other places, where the conditions had not been so favorable for the spread of the fire, the dead, barkless trunks of the trees were still standing, the tops broken and the branches fallen, the scene presenting at once a most impressive example of the destructive powers of an insect enemy of forests and of subsequent devastation by forest fires.

While the caterpillars, which were primarily to blame for this destruction, have not attracted attention in recent years, they will doubtless make their appearance again in destructive numbers and attack the remaining timber, which is becoming each year more accessible to lumbering operations, and hence rapidly increasing in value.

On page 17 further reference is made to the Buprestid enemy of the Hemlock, Red Fir, and Noble Fir:

"The evidence found in living, dying, and dead Noble Fir and Hemlock in the Cascade Forest Reserve at Berry, Oreg., and in Hemlock and Red Fir along the Columbia River in the vicinity of St. Helen, indicated that much loss of valuable timber had been due to the work of Buprestid larvæ in the living bark of these trees. The conditions at the time were not favorable for a study of this class of enemies or for a special investigation of the damage which seemed to be due to their attacks. It is, however, a subject of special importance, which will demand considerable attention in the future. Specimens of larvæ collected from the bark of living trees were provisionally identified by Mr. Schwarz as belonging to the genus

Melanophila, probably *M. drummondi*, which is closely allied to *M. fulvoguttata*, a destructive enemy of the Hemlock in West Virginia. An undetermined Cerambycid bark-borer was found associated with the Buprestid larvæ in Hemlock and Red Fir, but the evidence pointed to the Buprestid as having made the first attack."

These bark-infesting enemies are again referred to by me in the Forester, Volume VII, October, 1901, page 251, as follows:

"The Douglas Spruce bark-borer (*Asemum nitidum* Lec.), the Western Hemlock bark-beetle (*Hylesinus tsugæ* Hopk. MS.), and the Western Hemlock bark-borer (*Melanophila drummondi* Kirby), infest the living bark, and either kill the trees or cause gum-spots in the wood of the Douglas Spruce and Western Hemlock in Oregon and Washington."

They are again referred to in the Proceedings of the Society for the Promotion of Agricultural Science, 1891, pages 66, 67, under the head of "Some Insect Enemies of Living Trees," as follows:

"The Western Hemlock bark-beetle (*Hylesinus tsugæ* Hopk. MS.) attacks the living trees, and either kills them or causes defects known as gum spots in the wood of the Western Hemlock. It is found at Newport, Oreg., and Port Angeles, Wash.

"The Douglas Spruce bark-borer (*Asemum nitidum* Lec.) is a round-headed bark-boring grub, the larva of one of the long-horn beetles. It was found to be a very common enemy of the Douglas Spruce and Western Hemlock in western Oregon and Washington. The healed-over wounds in the living bark cause gum-spot defects in the wood, and the trees die from successive attacks.

"The Western Hemlock bark-borer (*Melanophila drummondi* Kirby) is a medium-sized flat-headed bark-boring larva of a Buprestid beetle. This insect excavates shallow winding burrows through the inner layers of bark of living Hemlock and Douglas Spruce. It was observed from California to northern and eastern Washington and western Idaho. This is a very common enemy, killing the largest and best trees or causing serious gum-spots in the wood of those which survive its attack."

BORING BEETLES.

Among the wood-boring beetles and flat and round headed wood-boring grubs, there are numerous species which cause more or less injury to the wood of living, dying, and felled trees. The wood-boring beetles cause pin-hole defects and bluing of the wood, which result in considerable loss to the manufacturer of lumber from this tree.

Much of this loss can be prevented by removing the bark from the logs of trees which are felled or remain in the woods for some time after the 1st of April, since, as a rule, most of these insects will attack only trees and logs which have the bark on.

It is the intention to make a special investigation during this summer to determine, if possible, the exact species to blame for the defoliation of the Hemlock and Douglas Spruce in western Oregon and Washington. Further investigation will also be made of the other insect enemies of the Hemlock and other forest trees of that region, the results of which will appear in a forthcoming bulletin of the Division of Entomology.

A tradition around Grays Harbor accounts for the disappearance of the insect that defoliates the Hemlock by affirming that the females are wingless, and, as the immense numbers rapidly destroyed the food supply, were unable to travel fast enough to reach fresh pastures before the males had eaten everything clean. This story is of some interest, inasmuch as there are species of Geomterid in which the

females have abortive wings, and a clue to the identity of the moth is suggested. It is also quite possible that it is founded only on ignorance of the history of insects and the supposition that the moth and caterpillar were of different sexes.

Were it possible to identify this insect, enough might be known of its habits to warrant predictions of its behavior in the future; under the circumstances it is possible only to say that another attack may occur at any time. Aside from the direct loss, the destruction of so large a body of standing timber creates, as suggested by Dr. Hopkins, a fire trap, which menaces the forests of the surrounding region, and it is quite possible that many of the former large fires of the coast region were due to this cause. With so great a rainfall and a dense green underbrush, the forest seldom, if ever, becomes dry enough to burn without some unusual aid, yet there is abundant evidence that the whole region has been swept clean by fire. It is difficult in any other way to account for the existing stand of old red fir, since it is a species which requires open ground for germination.

BLACK CHECK.

In 1900 the larvæ of an insect were discovered living in the bark and apparently causing a serious injury known as black check. Investigation showed this process in all its stages—the fresh wound, with the grub at work in it, partially covered scars of a year or two ago, and blackened spots buried several inches where they would be opened if the log came to the saw. The presence of larva is always betrayed by a flow of resin. Several specimens were collected and were identified by Messrs. Coquillot and Schwarz, of the Division of Entomology, as an unknown species of the family of Syrphidæ, genus Xylota. Since it is the habit of this genus to lay its eggs in the galleries of bark beetles, it seems probable that this species obtains entrance in the same way, although no evidence was found to show previous occupancy of the burrows. As such insects are often secondary and not originally responsible for the injury which is attributed to them, careful search was made for similar burrows not occupied by the Xylota larva, but none were found in an investigation carried on for several months. The most plausible explanation is that the female deposits the egg in the gallery of some Scolytid which does little or no damage to the tree, and that the attack on the wood is made by the Xylota larva upon emerging from the egg. In the fall the larva leaves the cavity and buries itself in the mass of pitch which has collected outside the bark, there assuming the pupal stage.

The only forest region found wholly free from this enemy was a belt along the west slope of the Cascades, above an elevation of 1,800 feet. If altitude proves responsible for this immunity, a similar region in the Olympics will probably also be found free from attack.

The danger is lessened by thick bark, which renders it difficult for the insects to enter. For the same reason large trees are safer than small ones. They are frequently streaked near the center, but not toward the outside, showing that when the tree reached a certain size its bark became thick enough to protect it. (Pl. VII, fig. 1.) As yet protective measures against this insect are unknown, but much disappointment might be prevented by an examination of standing timber for traces of the insects. It is useless for manufacturers of cooper stock or finishing lumber to buy infected logs. The presence of the larva in the standing tree is always apparent to a close observer.

IMMUNITY FROM WHITE ANTS (TERMITES).

Experiments made in Manila indicate that Hemlock may prove of special value in tropical countries where most woods are destroyed by ants. Capt. George P. Ahern, chief of the Philippine forestry bureau, states in a recent report that the master mechanic of the depot quartermaster's shops, Mr. D. N. McChesney, tested several American woods by thirty days' exposure to the attack of ants with the following results:

Oregon Pine (Red Fir)	Entered and eaten; a mere matter of time for complete destruction.
Bull Pine, Spruce	Eaten more readily than Oregon Pine.
California Redwood, California White Cedar	Ants tried, but discontinued after slight effort.
Hemlock	Not touched.

Further experiment is now being made. Since the depredations of ants are of great importance, not only in the Philippines but in other tropical countries, a wood which will withstand them is certain of a good market. Although Cedar and Redwood have the reputation of being ant proof, they are not adapted to many uses for which Hemlock is excellent.

For many years farmers have used Hemlock for the construction of oat bins and similar receptacles designed to be rat and mouse proof. It is said that the wood is distasteful to all rodents.

PARASITES.

A parasite (*Arceuthobium occidentale*) resembling mistletoe is widespread throughout the Hemlock region. It grows upon the branches and leading shoots, causing distortions and occasionally death. When the branches only are attacked, the result is a disturbance of their functions, and consequently a slow, sickly growth of the tree, which, however, does not affect the quality of the timber. If, however, the plant gets foothold on the leading shoot, a burl follows which persists

FIG. 1.—FASCIATION OF HEMLOCK BRANCH, CAUSED BY ARCEUTHOBIUM OCCIDENTALE.

FIG. 2.—HEMLOCK STUMP, CUT HIGH TO AVOID GROUND-ROT.

throughout the life of the tree and not only ruins a log, but renders the tree apt to be broken by the wind. (Pl. VI, fig. 2.)

The mode of propagation of Arceuthobium is curious. Male and female flowers are on separate plants, and the fruit, borne late in the fall, is a berry containing a sticky seed. When ripe, but only in dry weather, the berry explodes, throwing the seed several feet. If it happens to strike the branch of the same or another Hemlock, its glutinous covering enables it to adhere until it germinates and forces roots through the bark of its host. Since this is possible only on the thin, tender bark of young wood, the older portions of the tree are exempt. After a few years the parasite dies, but the distortion caused by it remains and the branch dies or remains permanently diseased. Its lateral growth usually stops and a fan-like mat of twigs radiates from the injured portion. (Pl. VIII, fig. 1.)

In a few coast districts and cool mountain valleys the Arceuthobium renders the Hemlock practically worthless, and by covering the ground with fallen trees and branches increases the danger from fire. The enfeeblement of the trees doubtless also facilitates the entrance of fungous diseases. Where the parasite is abundant, the trees die at the top and their crowns become tufted and narrow. It does not generally occur in sufficient quantity to be of economic importance and need not enter into a discussion of the use and future of Hemlock.

THE WOOD.

There is little similarity between the wood of the Eastern and Western Hemlock. That of the Western tree is light, rather hard, straight grained, tasteless, tough, and usually white, although often reddish-brown in the interior of the tree. This discoloration is not confined to the heartwood, but may extend into the sap, and is usually darkest where it does so. It is a serious defect in timber which is used for pulpwood, for finishing, or as a substitute for Spruce. Trees thus affected are commonly known by lumbermen as "Black Hemlock," and are frequently believed to be a different species. This does not refer to the true Black or Alpine Hemlock, which grows only at great altitudes and is not yet available for lumber.

In strength, ease of working, and freedom from warp and shake, Western Hemlock differs greatly from the Eastern species, whose deficiencies in these respects are its chief drawbacks. Western Hemlock can not be classed in strength with Oak, Red Fir, or Longleaf Pine, nor is it suitable for heavy construction, especially where exposed to the weather; but it possesses all the strength requisite for ordinary building material. It is largely used in Washington for mill frames.

When green, Hemlock contains much water and is very heavy; when dry it is but little heavier than Spruce, in some localities no heavier.

The following table gives the weights of thoroughly kiln-dried Hemlock and that of four well-known woods, per cubic foot:

TABLE 1.—*Weight per cubic foot of Hemlock and other well-known woods.*

	Pounds.
Western Hemlock	26.95
Eastern Hemlock	26.42
White Pine	24.02
Sitka Spruce	26.72
Red Fir	32.14

The weight given for Western Hemlock is the average of 1,500 feet B. M. taken from different Cascade camps at different times, and was obtained by a member of the Bureau of Forestry. The weights of the other species are quoted from the Tenth Census of the United States, Vol. IX. The weight of Hemlock varies greatly with locality and rate of growth, and in the tree itself.

DURABILITY.

The durability of this timber is still largely a matter of conjecture. There are no recorded experiments, and it has until recently been but little used. It is probable, however, that its durability has been greatly underrated. Although not a hardwood, it has given satisfactory service in floors for several years. It is the general experience that Hemlock skids, dams, and bridges in the woods are short lived, but this may be in part because the wood is used unbarked and never becomes dry. Green Hemlock is exceedingly sappy, heavy, and liable to attack by fungi and insects. It is not adapted for use partly in the ground. While the popular prejudice has prevented its extended use for piles, a few instances go to prove that Hemlock piles last almost if not quite as long as those of Fir. In salt water both stand until destroyed by teredoes or limnoria; in fresh water Hemlock lasts about ten years. Hemlock is, however, softer than Fir and more apt to be crushed in driving, and is less able to withstand a great strain successfully. In ease of working it is between Fir and Spruce, taking a smoother surface and cutting more easily than the former. It is readily turned, and the straight, even grain renders it free from brashiness or tendency to chip. There is very little contrast between the hard and the soft grain, and this feature, with the absence of pitch, makes it susceptible of a beautiful finish.

DEFECTS.

The chief of these are "black streaks" or checks, black knots, and the red heart already described. The latter is serious when the infected wood is used for pulp, on account of the color of the product; as lumber, it is undesirable for ornamental work and prevents substi-

tution for Spruce. It is, however, easily detected and the logs may be scaled down accordingly. The black knots, due to a fungous disease occurring where shade-killed branches have improperly healed, almost wholly ruin the lumber in which they occur. They are, however, confined mostly to trees near the coast. The black streaks, which have resulted in bewilderment and consternation on the part of those who have tried to manufacture finer articles of Hemlock, is a widespread and serious evil for which no remedy is as yet apparent. They are from three-quarters of an inch to 3 inches long, seldom over five-eighths wide, and very thin. (Pl. VII, fig. 1.) The streaks lie with the grain and become very conspicuous if the log is bastard sawn. In boards cut across the grain they are less conspicuous, but kiln drying is apt to open them clear through the board and to render the latter useless where tightness is required. This is one of the chief objections to the use of Hemlock for woodenware, for which it is otherwise excellent. This defect, varying greatly in degree, is widespread throughout Washington and Oregon and necessitates care in the selection of Hemlock from certain localities. It is less prevalent upon the higher slopes of the Cascades, while toward the upper limit of the tree the defect does not occur.

Besides the three defects mentioned above, Hemlock lumber frequently shows the perforations of boring beetles. This is, however, usually the result of careless handling of the logs and is too local in distribution to be quoted as an objection to Hemlock lumber generally.

USES.

Hemlock is best adapted for uses which require ease of working, a handsome finish, and lightness combined with considerable strength. It has been found suitable for flooring, joists and scantling, laths, siding, ceiling, box shooks, turned stock, newel and panel work, woodenware, and paper pulp. It is, however, for finishing and box manufacture that it is most certain of appreciation when it becomes better known. Taking a high polish, free from pitch, and, when properly sawed, showing a beautiful grain, it is an excellent wood for wainscot, panels, and newels. It is harder and less easily dented than Redwood or Cedar, and has a uniformly firm grain which on drying does not show the minute corrugations characteristic of Red Fir and other trees having a marked difference between summer and fall wood. The St. Paul and Tacoma Lumber Company, of Tacoma, has an office finished in Hemlock which attracts much admiration, and builders of many stores and residences on Grays Harbor have selected it as the most ornamental of Western woods for inside finishing.

Of greater economic importance, however, is the use of Hemlock as a substitute for Spruce and White Pine in the manufacture of boxes. The scarcity of timber suitable for this purpose is a cause of much

concern even in the West. The United States Geological Survey estimates the quantity of standing Spruce in Washington at less than 6½ billion feet. Oregon contains much less. Spruce is in demand for pulp as well as for box material and woodenware stock, and the available supply is going rapidly. Spruce logs are the dearest in the market, and Spruce is not easy to get at any price.

Hemlock is not used for pulp in Washington. Probably half the quantity now sawed in that State goes into "Spruce" boxes, for the manufacture of which it is admirably adapted in color, weight, and tastelessness. The objections are that very thin stock is more apt than Spruce to split and that on account of "black knots" only clear lumber can be used. The latter objection is confined mainly to timber from near the coast. With the failing supply of Spruce the necessity for the general use of Hemlock becomes urgent, but so far few manufacturers have had courage to use it under its own name, and its substitution for Spruce can be carried on only to a limited extent. Were it well understood that Hemlock boxes are practically as light and tasteless as those of Spruce, a market for Hemlock would be opened immediately. An evidence of the adaptation of Hemlock for food packages is the fact that early settlers in Washington invariably used it for hewn tubs in which to pack their winter butter.

After considerable experiment a large paper mill at Lowell, Wash., has decided unfavorably against Hemlock. On the other hand, it is largely used in Oregon, where it is pronounced better than the Eastern species. Since it is impossible altogether to avoid red-hearted or "black" logs, the color is the chief objection and makes the use of ground Hemlock pulp impracticable for the manufacture of better grades of paper, although soda and sulphite processes bleach the wood sufficiently unless it is unusually bad. The Oregon mills buy only upland logs. Those from the coast are apt to be faster grown, of coarser fiber, darker, and more frequently affected by black knots. Several camps in Oregon put in large quantities of Hemlock for pulp alone and receive on an average $4.50 per thousand. The bark is frequently given away on condition that it be removed from the log. It brings $10 to $12 a cord at the tannery.

MANUFACTURING PROBLEMS.

PRESENT MARKET STANDING.

Except to a limited extent for pulp, Western Hemlock is at present absolutely without standing in the market. A few million feet are cut annually, but are manufactured and sold under the name of Spruce or Fir. It is a breach of confidence for the logger to disclose the name of a customer to whom he sells Hemlock. It is never quoted in local trade journals. Notwithstanding these facts, mill men almost uni-

versally admit that they consider it an excellent timber and deplore the conditions which prohibit its use. There are three main reasons for this state of affairs:

(1) The prejudice of the consumer, who condemns Hemlock without trial because of its name.

(2) Hitherto Fir and Spruce have been so cheap that there has been no necessity for using Hemlock.

(3) Hemlock is heavy when green and apt to give trouble in driving and in ponds.

To overcome the prejudice against the name will be difficult, for to introduce an unknown timber to the market usually requires years. The practice of selling Hemlock as Fir when manufactured into flooring, siding, and dimension stuff, and as Spruce in the form of box-shooks and woodenware, has grave drawbacks. If detected, as he frequently must be, the mill man must either lose a customer or bring satisfactory proof of the excellence of the Hemlock. If he is able to accomplish the latter, he might as well have done so originally and the problem would thus have been solved. A mill which makes the substitution also furnishes a weapon of revenge to rivals and to employees with a grievance. It works a hardship to timber owners; for, with no recognized price for the timber, they are at the mercy of the mills. Some individuals have decided that, as the name is the drawback, it should be changed; and an attempt has been made to introduce Hemlock as Alaska Pine. This has been successful to some extent, and if it had been attempted earlier might have solved the problem.

The second reason no longer exists. The standing timber of the Northwest is going into the hands of large holders, either mill companies or speculative syndicates, and the day of the small logger, who moved from claim to claim, taking only the best timber, will soon be over. Under the old system, when the logger bought the stumpage, he found it most profitable to take only the best Fir and leave a fair merchantable grade uncut. An apparently unlimited supply enabled him to continue this wasteful system. Under such conditions it was not surprising that Hemlock was neglected. As a rule, it furnishes less clear lumber than Fir, and when only the best of the latter species was taken at a cost to the mill but little more than that of logging it, the utilization of Hemlock was out of the question. It was never cruised, and was left as entirely unconsidered in the buying and selling of timber land as though it did not exist. Now, however, it is becoming more and more the rule for timber to be cut by its owner, or, if not, to be sold by the acre, and it is to the interest of the logger to cut all he can from the land. In the case of Fir, lower stumps and shorter tops are put on the landing which would not have been looked at ten or even five years ago. The owner also realizes that a log of Hemlock used is a Fir log saved, and the only question is how to dispose of it.

The third objection will be discussed under the head of lumbering. There is little doubt that if Hemlock logs brought $5 a thousand, even the heavy butts would find their way to market.

ACCESSIBILITY.

A restricted home demand and remoteness from other markets are the chief difficulties before the lumber manufacturer in Oregon and Washington. Although timber is cheap, labor is high, and to sell his lumber he must place the price so little above the cost of logging and manufacture that the business is one of uncertainty and slender profit. The result is that although lumbering is carried on upon an immense scale, the State is being denuded of its timber with little profit beyond the employment of the men engaged in producing the lumber. The owner gets little for his timber, and the mill man receives an income trifling when compared with his investment and risk.

The reason for this is the cost of transportation. The manufacturer is obliged to depend upon the foreign cargo trade, the Eastern market accessible by rail, and locally upon Alaska and California. The latter is the dumping ground for side and common lumber which can not be profitably shipped a long distance. The cargo trade is peculiar in that the market is fairly steady and no great energy in pushing the product is required, but it is governed very largely by ocean freight rates. If grain be moving the lumber shipper will find it impossible to charter a vessel. Owners dislike to load lumber, both because it is supposed to be bad for the ship and because it often takes her to a port which furnishes no return cargo. If, on the other hand, the prospect for grain on the Pacific coast is bad, ships do not come there at all unless under charters which fully recompense them. The effect is that when rates are favorable the mills accept all the orders they can secure, make charters regardless of possible forfeit through delay, and run day and night, piling up immense amounts of nearly unsalable lumber. When matters turn the other way, the mills may run for months at a loss or with little profit so far as the cargo trade is concerned.

The following freight rates on lumber from the northern Pacific coast ports to foreign ports, for September, 1899, and September, 1900, are quoted from the San Francisco Commercial News:

TABLE 2.—*Freight rates on lumber from northern Pacific coast ports to foreign ports.*

	RATE PER 1,000 FEET, SEPTEMBER, 1899.
From Puget Sound to—	
Sydney, New South Wales	$11.25 to $11.75
Melbourne or Adelaide	13.12 to 13.43
Port Pirie, Australia	12.50 to 12.81
Freemantle, West Australia	15.93 to 16.25
Geraldton, West Australia	16.25 to 16.56

From Puget Sound to—	
West coast South America:	
Pisaqua range	$12.81 to $13.12
Callao range	13.12 to 13.43
Buenos Ayres	13.75 to 15.00
Shanghai	13.43 to 13.75
Kiaochow	13.75 to 14.06
Japan	12.50 to 12.81
South Africa	15.62 to 16.25
United Kingdom	17.50 to 18.12
Vladivostok	12.50 to 12.81

RATE PER 1,000 FEET, SEPTEMBER, 1900.

From northern Pacific coast ports to—	
Sydney, New South Wales	$13.12
Melbourne or Adelaide	15.00
Port Pirie, Australia	$14.37 to 15.00
Freemantle, West Australia	17.50
Geraldton, West Australia	17.81
West coast South America:	
Pisaqua range	15.62 to 15.93
Callao direct	15.31
Buenos Ayres	17.50 to 17.81
Shanghai	16.25
Kiaochow	17.50
Nagasaki, Japan	15.00
South Africa	18.12 to 18.75
United Kingdom	21.25
Vladivostok	16.25

Rail trade with the East is affected by a more fluctuating market and by vigorous competition, but is also regulated almost wholly by the cost of transportation. Except for the business in spars and heavy timbers, which are obtainable only on the Pacific coast, the eastern limit of trade is that point to which Oregon and Washington lumber can be delivered more cheaply than Southern or Northern Pine. The rate on Fir lumber from Puget Sound and Oregon at present is:

TABLE 3.—*Railroad rates on Fir lumber from Puget Sound and Oregon, per 100 pounds.*

Helena	$0.35	Pittsburg	$0.65
St. Paul	.40	New York	.73
Chicago	.50	Boston	.75
St. Louis	.52½		

Lumber other than Fir is, as a rule, 10 cents less per hundred pounds. This at present applies only to Spruce and Cedar, since these are the only other kinds which are shipped.

With the cost of logs at about $6 and of manufacturing at $3.50 per 1,000 feet B. M. these freight rates allow of little shipping of timber from west of the Rockies, although there is a prospect that satisfactory rates will soon be granted to Missouri River points. The bulk of the

lumber shipped to these points is for building purposes, for which Western Hemlock is thoroughly satisfactory. Since dry Hemlock (rough) weighs but 2,240 pounds per 1,000 feet B. M., and Fir weighs 3,000 pounds, the theoretical saving in freight on kiln-dried grades would be nearly one-fourth. The arbitrary weights accepted by the railway companies for the various grades of Fir might conflict somewhat with this comparison, but the advantage for long hauls in a decrease in weight of 20 per cent remains indisputable. The difference in the weight of air-dried stock of these two kinds may be less, since Hemlock is slow to dry and heavy when green, but with proper care it would still be considerable. Generally speaking, Hemlock lumber will probably be sold in the Missouri region from $2 to $3 cheaper per 1,000 feet B. M. than Fir on account of saving in freight alone.

LUMBERING.

With a few exceptions, it is only as skid timber that Hemlock enters the logger's calculations. These exceptions are where mills log their own lands, where small orders for box lumber or pulpwood are received, or where the Hemlock is unusually good. In all cases it is put in as a side product with a much larger quantity of Fir, for no logging is done in approximately pure Hemlock stands.

So far as Hemlock logs can be quoted at all, they bring about $4.50 per 1,000 feet B. M. for the largest and clearest, no others being handled. Fir of the same quality is worth $6 to $8. Most frequently the Hemlock logs are not classed as Hemlock, but are put in with the Fir and scaled at the option of the buyer as first or second grade Fir. A few camps put in from four to five logs a day, cutting only those they are sure will be accepted at the price of first-grade Fir. To sum up, the demand is so small and uncertain that the logger handles Hemlock only in a desultory and unsystematic way.

As a rule, there is little profit in logging on Puget Sound for less than $5 a thousand, and it actually costs many Red Fir camps $5.50 to deliver their logs at the mill. On Grays Harbor and the Columbia River the cost is a little lower. It is idle to attempt to state definitely the cost or profit of lumbering, since it varies from a net gain of $1 a thousand to losses resulting in bankruptcy; but the following table gives a rough average of the cost of lumbering 1,000 feet at Puget Sound camps:

TABLE 4.—*Average cost of lumbering per 1,000 feet at Puget Sound camps.*

Stumpage	$1.00	Average price of logs	$6.00
Labor	2.50	Cost	5.50
Engines, line, and road	1.00		
Haul to mill	1.00	Profit	.50
Total	5.50		

There is apt to be considerable variation in the items of expense. Timber lying on streams may bring $1.50 stumpage; that accessible only by rail is cheaper, but the cost of transportation often reaches $1.50. Estimates for the cost of engines, line, and road vary from 50 cents to $1 per 1,000 feet B. M., but probably the latter figure is more nearly correct. The scarcity of accessible timber makes private logging roads necessary in most instances, and these cost from $5,000 to $10,000 a mile. The expense for railroad per 1,000 feet B. M. depends upon the amount of timber rendered available and is exceedingly variable. The length of the haul and the character of the ground make a considerable variation in the outlay for wire rope. The following table, based upon an actual pay roll, shows the cost of operations in a camp which ships logs by rail and water to a distant mill:

TABLE 5.—*Cost per thousand feet.*

Labor getting logs to car	$2.50
Shipping to boom	1.30
Booming and rafting	.08
Scaling	.035
Returning boomsticks	.07
Mill discount	.11
Wear on outfit	.50
Total	4.595

This is exclusive of stumpage, which in this instance was 50 cents per 1,000 feet B. M., the timber having been purchased several years ago. The same timber is now worth about $1.

It would thus appear that with Hemlock logs at $4.50, or even $5, there is little profit in logging them. It is to be remembered, however, that a portion of the expense of lumbering, such as the cost of a railroad, is necessary in order to lumber the Fir, and thus can not be charged altogether against the Hemlock; and when, as is often the case, no account was taken of Hemlock when the timber was purchased, the cost of stumpage is also eliminated.

The difficulty of driving butt logs, because of their weight, deters many lumbermen from handling Hemlock. This difficulty varies greatly, and in many localities is of no importance. Hemlock near the coast is heavier when green than the Hemlock of the uplands, and, since river driving is also commoner there, gives the most trouble. Were the demand regular and extensive, however, means of avoiding this difficulty would doubtless be devised. A market for Hemlock bark would probably make it profitable to peel the logs in summer, and they would then dry out sufficiently to be driven successfully. There would then, however, be the danger from the boring-beetles, which have already been mentioned.

Hemlock, unless cut with the Fir, is usually lost. Fire is practically certain to run through the slashings. The thin bark of the Hemlock makes a severe fire fatal, and where a tree is only slightly scarred the boring-beetle is almost sure to attack it. With its shallow root system the Hemlock is also liable to be blown down when left unprotected, and even the drying of the soil, due to increased light, often proves fatal.

It is not uncommon for 5,000 to 25,000 feet of Hemlock per acre to be left standing on land from which the Fir has been removed. Allowing a stumpage value of only 25 cents per thousand feet, this represents a loss of $1.25 to $6.25 an acre. Or, putting it differently, if Hemlock gains a place in the market, it will raise the value of such timber from $1.25 to $6.25 an acre. In the case of pure, or nearly pure, Hemlock, a greater increase in value would be necessary to bring about the same result, for there would be no logging of Fir to lower the cost of logging the Hemlock. (Pl. IX.)

VOLUME AND YIELD, FIRST-GROWTH HEMLOCK.

Scribner's scale has been used in all volume and yield tables in this report. The universal custom of scaling at the small end of the log has been followed, although the scale was originally intended to be applied at the middle, where it is far more accurate. The prevailing practice undervalues large logs, and it is probably for this reason that the mills secured its adoption; but a return to the correct method here would result only in confusion.

The data for Table 6, which gives the contents of standing trees in board feet, were obtained by two methods, one based on the actual logging practice and one on the possible merchantable contents of the trees. The former included the scaling of several hundred trees as they lay in the slashings, cut into logs but not yarded out. The logs were scaled just as would be done by the camp or mill scaler, except that the total contents of each tree were kept separate. In this way the average contents of trees of different diameters and height were found. The average diameter limit in the tops to which the Hemlock was cut was 20.5 inches. In this way from 10 to 30 feet of merchantable, and sometimes clear, lumber is usually left, which will undoubtedly be used when Hemlock is better appreciated. The same trees were therefore also scaled to a point 16 inches in diameter inside the bark, unless the crown extended below this point, when the merchantable length was considered to end at the first large green branch. Table 6 gives the result of both methods.

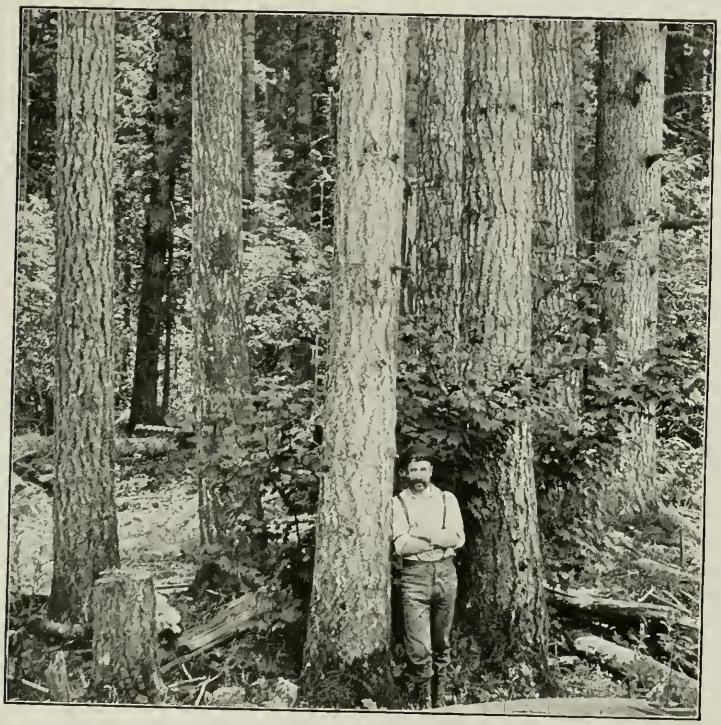

FIG. 1.—SECOND-GROWTH RED FIR, 70 YEARS OLD, DRYAD, WASH.

FIG. 2.—MATURE RED FIR, 380 YEARS OLD; YOUNG HEMLOCK BENEATH, BLACK HILLS, WASHINGTON.

TABLE 6.—*Merchantable length and contents.*

Diameter breast-high.	Average total height.	Merchantable length.		Contents.	
		In practice.	Cutting to 16 inches.	In practice.	Cutting to 16 inches.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Board feet.*	*Board feet.*
20	135	.....	24	.....	240
21	140	.....	34	.....	350
22	144	.....	43	.....	465
23	148	37	52	550	580
24	152	44	60	680	700
25	156	51	68	800	825
26	159	58	74	920	955
27	162	63	80	1,040	1,090
28	166	68	84	1,150	1,230
29	168	71	87	1,260	1,365
30	171	73	89	1,360	1,490
31	174	74	91	1,450	1,605
32	176	74	92	1,540	1,715
33	178	75	93	1,630	1,820
34	181	75	93	1,710	1,925
35	183	75	94	1,780	2,030
36	185	76	95	1,850	2,135
37	187	77	96	1,920	2,245
38	189	79	97	2,000	2,360
39	191	81	98	2,080	2,480
40	193	83	101	2,175	2,605
41	194	86	103	2,280	2,735
42	196	89	106	2,400	2,870
43	198	90	109	2,550	3,010
44	199	91	112	2,730	3,160
45	200	92	115	2,940	3,320
46	202	93	119	3,175	3,490
47	203	94	123	3,430	3,670
48	205	95	126	3,680	3,870
49	206	96	131	3,920	4,090
50	208	97	135	4,155	4,310

In this table small trees appear to scale much too high in proportion to the larger ones. This is because only unusually tall and good trees of the smaller diameters are taken at all, and their average is relatively high, while above 30 inches practically all sound trees are cut.

To the logger who profits only on the number of feet he sells, Table 6 shows that his possible gain in feet, board measure, by cutting higher into the tops is small, even assuming he has a market for timber of the quality he would obtain thereby. A mill cutting its own timber would gain much more, for the inconsistency of the log scale is such that the table does not show the actual difference in the amount of wood saved by cutting to 16 inches. For example, a log 40 feet long and 16 inches in diameter at the small end, scaled by the Scribner Rule, contains 396 board feet. If 10 feet are cut off the small end of the log, allowing 2 inches taper for this distance, the log will be 30 feet by 18 inches, and will scale 400 board feet, an apparent gain of 4 feet by throwing away a log 10 feet by 16 inches. In sawing long

logs this discrepancy is in part justified by the loss in slabs, but there is no question but that on the whole a mill would gain more by cutting to a 16-inch limit than is shown by Table 6. The average difference in the merchantable length between cutting to 16 inches in the top and cutting as it is now done is shown to be from 15 to 20 feet.

The following table gives, on a basis of diameter breasthigh, the total height, length of crown, and merchantable length of Hemlock grown under cover and standing free:

TABLE 7.—*Total height, length of crown, and merchantable length.*

Diameter breast-high.	Under cover.			Standing free.		
	Total height.	Length of crown.	Merchantable length cut.	Total height.	Length of crown.	Merchantable length cut.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
8	.....	.....	.....	59.0	21.0	.....
9	.....	.....	.....	67.0	24.0	.....
10	.....	.....	.....	75.0	29.0	.....
11	.....	.....	.....	83.0	34.0	.....
12	.....	.....	.....	90.0	38.5	.....
13	.....	.....	.....	97.0	43.5	.....
14	.....	.....	.....	104.0	48.0	.....
15	.....	.....	.....	110.0	52.0	.....
16	.....	.....	.....	116.0	55.5	.....
17	.....	.....	.....	121.0	58.0	.....
18	.....	.....	.....	126.0	60.5	.....
19	.....	.....	.....	131.0	63.0	.....
20	135.0	77.5	37	135.0	64.5	.....
21	140.0	79.0	47	140.0	66.5	.....
22	144.0	80.0	51	144.0	68.0	.....
23	148.0	81.0	37	148.0	69.0	37
24	152.0	82.0	47	152.0	70.5	44
25	156.0	83.0	51	156.0	72.0	51
26	159.0	84.0	58	159.0	73.0	58
27	162.5	85.0	63	163.0	74.0	63
28	166.0	86.0	68	166.0	75.0	61
29	168.5	86.5	71	169.0	76.0	68
30	171.5	87.5	73	171.0	76.5	73
31	174.0	88.0	74	174.0	77.0	74
32	176.5	89.0	74	176.0	77.5	74
33	178.5	89.5	75	178.0	78.0	75
34	181.0	90.0	75	181.0	79.0	75
35	183.0	90.5	75	184.0	79.5	75
36	185.0	91.0	76	186.0	80.0	76
37	187.0	91.5	77	188.0	80.5	77
38	189.0	92.0	79	190.0	81.0	79
39	191.0	92.5	81	191.5	81.0	81
40	193.0	93.0	83	194.0	81.5	83
41	194.5	93.5	86	196.0	82.0	86
42	196.0	94.0	89	198.0	82.5	89
43	198.0	94.5	90	200.0	83.0	91
44	199.0	95.0	91	202.0	83.0	92

The following table gives, on a basis of diameter breasthigh, the percentage of the total volume of wood and bark of Hemlock, excluding branches, which is merchantable under present logging methods:

TABLE 8.—*Utilization under present logging methods.*

Diameter breast-high.	Merchantable contents.	Diameter breast-high.	Merchantable contents.	Diameter breast-high.	Merchantable contents.
Inches.	*Per cent.*	*Inches.*	*Per cent.*	*Inches.*	*Per cent.*
20	45	31	65	42	73
21	49	32	65	43	74
22	53	33	65.5	44	75
23	55	34	66	45	76
24	58	35	66	46	77
25	60	36	67	47	77
26	61	37	68	48	77
27	62	38	69	49	78
28	63	39	70	50	78
29	64	40	71		
30	64.5	41	72		

The following table gives for Hemlock, on a basis of diameter breasthigh, the length of that part of the stem, including the stump, which will yield clear lumber, according to market specifications:

TABLE No. 9—*Diameter and length of stem yielding clear lumber.*

Diameter breast-high.	Yielding clear lumber.	Diameter breast-high.	Yielding clear lumber.	Diameter breast-high.	Yielding clear lumber.
Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
20	27	27	46	34	56
21	31	28	48	35	56
22	34	29	50	36	57
23	37	30	51	37	58
24	40	31	52	38	59
25	42	32	53	39	60
26	44	33	54	40	61

Since the utilization of Hemlock where it occurs in mixture with Fir is of chief importance at present, no consideration is given here to the utilization of pure stands of mature Hemlock. The stand is given for localities where logging is most active and represents different types of the mixtures of Fir and Hemlock which form the larger part of the commercial forests of the Pacific Northwest. The percentage of Hemlock in the merchantable stand varies from 23 per cent at Orting to 59 per cent at Buckley. With Wilkeson these localities may be taken as a fair index to the stand of Hemlock on the western foothills of the Cascades, where the altitude is from 800 to 1,500 feet and the annual rainfall about 50 to 60 inches. The other places near which measurements of the stand were made were Hoquiam and Elma in Chehalis County, near the coast; Little Rock in Thurston County, and

Matlock in Mason County. It will be noticed that the percentage of Hemlock is highest on the coast and on the foothills, which is in proportion to the increase in rainfall.

The data for estimating the stand given in the following tables were obtained by the strip valuation survey method, which is in general use by the Bureau of Forestry. Strips 1 chain (66 feet) wide and 10 chains long to the acre were run in several directions through the forest to be estimated, and all trees on these strips were counted and measured at breastheight by calipers, or with a measuring tape, a separate tally being kept for each acre. At Orting, for example, the camps of the St. Paul and Tacoma Lumber Company were taken as headquarters, and the valuation survey parties followed compass courses radiating from the camps as a center, like spokes from the hub of a wheel. Since eight of these strips make a mile, the 325 acres measured at Orting aggregate a strip over 40 miles long and 66 feet wide. The contents of the trees in these strips were computed from the volume tables, constructed from the actual scale of felled trees. By this system the stand on large areas can be determined with great accuracy and at small expense.

All trees 20 inches and over in diameter breasthigh were scaled, which in most instances probably gives a trifle higher total stand than would actually be cut at present, since trees less than 2 feet are now seldom taken. No attempt was made to figure locally the cull due to unsoundness, for it is so variable that only confusion would result. All living trees 20 inches and over in diameter were scaled, whether defective or not, and a cull of 20 per cent was deducted for crooked, scrubby, or otherwise poor trees.

The number of acres actually measured in each locality is given at the head of each table. It should be borne in mind that these were carefully distributed over a large area and so far as the number and size of the trees are concerned represent the stand with very fair accuracy. The actual merchantable yield in board feet is necessarily dependent upon the standard in cutting. The yield of bark is computed for merchantable Hemlock only and assumes that the trees will be peeled to a point 17 inches in diameter in the tops.

TABLE 10.—*Stand and yield per acre in typical localities.*

WILKESON (400-YEAR-OLD STAND.)

[Average of 35 acres.]

Species.	Number of trees—		Average diameter breasthigh of trees—		Maximum diameter breasthigh.	Yield of trees 20 inches and over in diameter breasthigh.	
	6 inches and over in diameter breasthigh.	20 inches and over in diameter breasthigh.	20 inches and over in diameter breasthigh.	6 to 19 inches in diameter breasthigh.		Lumber.	Bark.
			Inches.	*Inches.*	*Inches.*	*Bd. ft.*	*Cords.*
Hemlock	80.3	18.85	30.0	9.5	64	20,508	4.53
Red Fir	11.6	11.54	66.0	12.0	118	71,065	.....
Others	6.0	5.74	52.0	13.3	127	9,533	.....
Total	97.9	36.13	45.0	9.5	127	101,106	4.53

TABLE 10.—*Stand and yield per acre in typical localities*—Continued.

BUCKLEY (410-YEAR-OLD STAND).

[Average of 131 acres.]

Species.	Number of trees—		Average diameter breasthigh of trees—		Maximum diameter breasthigh.	Yield of trees 20 inches and over in diameter breasthigh.	
	6 inches and over in diameter breasthigh.	20 inches and over in diameter breasthigh.	20 inches and over in diameter breasthigh.	6 to 19 inches in diameter breasthigh.		Lumber.	Bark.
			Inches.	*Inches.*	*Inches.*	*Bd. ft.*	*Cords.*
Hemlock	84.34	20.48	33.5	10.3	86	27,361	6.46
Red Fir	10.37	10.32	67.0	6.7	116	67,180	.....
Others	6.12	3.7	46.9	11.5	102	5,254	.....
Total	100.82	34.5	47.4	10.3	116	99,795	6.46

ORTING (250-YEAR-OLD STAND.)

[Average of 325 acres.]

Hemlock	43.78	10.86	27.8	10.1	92	9,800	2.06
Red Fir	29.35	24.08	40.0	14.4	116	48,080	.....
Others	19.89	11.48	37.0	11.8	228	9,809	.....
Total	93.0	46.4	37.0	10.9	228	67,689	2.06

ELMA (280-YEAR-OLD STAND.)

[Average of 87 acres.]

Hemlock	61.7	7.32	28.1	10.3	50	6,798	1.64
Red Fir	15.3	14.54	46.0	14.1	114	43,490	.....
Spruce	.8	.54	55.1	12.4	114	2,732	.....
Cedar	6.6	4.15	38.0	13.4	108	6,972	.....
Total	84.4	26.55	40.0	12.6	114	59,992	1.64

MATLOCK (260-YEAR-OLD STAND.)

[Average of 297 acres.]

Hemlock	47.73	10.09	30.7	11.1	56	11,485	2.53
Red Fir	37.75	29.31	40.0	16.2	.....	58,525	.....
Others	2.4	1.38	47.3	11.3	132	1,960	.....
Total	87.88	40.78	38.2	12.2	132	71,970	2.53

LITTLE ROCK (390-YEAR-OLD STAND.)

[Average of 61 acres.]

Hemlock	46.2	14.41	29.4	11.2	56	14,986	3.31
Red Fir	23.8	23.85	41.0	15.1	106	50,480	.....
Cedar	10.1	4.34	35.0	12.9	51	5,902	.....
Total	80.1	42.6	36.2	13.1	106	71,368	3.31

HOQUIAM (400-YEAR-OLD STAND.)

[Average of 89 acres.]

Hemlock	50.2	10.09	34.3	11.2	54	13,972	3.42
Red Fir	9.83	9.77	65.5	13.1	120	59,160	.....
Spruce	1.18	1.01	63.0	11.4	112	6,194	.....
Cedar	1.5	1.37	56.5	13.3	114	5,370	.....
Total	62.7	22.24	50.7	12.3	120	84,696	3.42

For fairer comparison the merchantable stand of Red Fir given in the tables was computed according to the average diameter limit to which the Red Fir is cut throughout the State, and not, unless through coincidence, according to local practice. Except in the case of pile or spar camps and of a few small concerns supplying tie mills, there is no great variation in the diameter limit to which Red Fir is cut on the stump. Usually a forest stand in which most of the trees are not over 3 feet in diameter is not considered merchantable at all. A common standard considers no tree merchantable which will not cut two 24-foot logs, each of which will square 16 inches. The distance into the top to which the tree is utilized varies greatly, however. Since the cost of logging, or of transportation, the quality of timber, or the demand for logs of certain lengths, may influence the amount taken out of a tree of a given diameter, it follows that each camp has its own standard, and this standard may fluctuate.

The following table shows the diameter inside the bark in the top to which Red Fir was being cut in several of the largest camps in Washington at the time they were visited by the agents of the Bureau of Forestry:

TABLE 11.—*Diameter limit in tops.*

Locality.	Diameter.
	Inches.
Buckley	31.8
Orting	17.5
Matlock	25.7
Elma	26.8
Little Rock	27.4
Hoquiam	33.3
Average	27.1

It is evident, from the above table, that volume tables made at Orting and Hoquiam would produce widely different results if applied to the same stand.

LOGGED-OFF LANDS.

Hitherto the problem of dealing with logged-off land has been given uniform treatment by Western lumbermen. It has been the custom to sell the land which had value for agriculture for what it would bring, especially for grazing, and to abandon the rest. Large tracts of logged-off land have been sold for 40 cents an acre. Occasionally an owner pays taxes on such property, but he is the exception, and often has some peculiar motive for doing so, such as a desire to show a large acreage. Very few expect to log a second time.

Excessive taxation in the United States is one of the greatest obstacles to conservative forest management by private owners. In western

Washington, cut-over lands, valuable for the production of timber alone, are assessed at a value of from $1 to $5 an acre, at a combined county and State rate of from 15 to 30 mills on the dollar. Assessors may attempt to make a more reasonable adjustment, but are often prevented from doing so by the demand of the State for a revenue from these lands far out of proportion to that required from other property. The State takes no account of the annual decrease of standing timber from cutting, and continues to levy the same tax, although it must be borne by less valuable land each year. In Chehalis County alone 10,000 acres are annually cut over, yet the tax rate is unchanged. An attempt was made to get logged-off lands placed in a separate lightly taxed class, and to have the burden divided among other classes of property, but it failed.

Calculating logged-off land as worth $1 an acre, with the assessment at $3 an acre, and the rate at 2 cents, the cost of holding a quarter section of such land for fifty years would be $1,742, or $10.90 an acre. It is thus evident that the community offers little encouragement to the timber grower. Under such conditions few men will hold logged-off land. The effect of the system is to defeat its own end. The property reverts to the State for delinquent taxes and, still considered worthless and wholly unprotected, it is burned and reburned until it becomes a desert. The gain to the community would be much greater were the land assessed at 50 cents an acre and the tax collected. Statements furnished by the assessors of several timbered counties in Washington show the amount of cut-over land which has been abandoned to be as follows:

TABLE 12.—*Amount of logged-off lands abandoned.*

County.	Assessed value of standing timber per acre.	Assessed value of logged-off land per acre.	Combined State, county, and special tax rate per acre.	Logged-off land abandoned.
	Dollars.	*Dollars.*	*Mills.*	*Per cent.*
Chehalis	8.00–9.00	2.00	19	71
Clallam:				
Hemlock	2.00	1.00	29	[a]
Other species	8.00			
Clarke	5.00–10.00	2.50–5.00	27	[b]
Jefferson	3.00–10.00	1.00	28	20
King	3.00–10.00	2.50	20	[b]
Pacific	2.50–5.00	1.25	22–30	[c]
Pierce	4.00–6.00	2.00–2.25	20–30	[d]
Skagit	3.00–10.00	[d]	18	[e]
Whatcom	4.00–10.00	2.00–10.00	16	20

[a] None nominally abandoned. Much delinquent.
[b] None.
[c] None at present. Indications that large amount will be abandoned.
[d] Information wanting.
[e] Very little.

The laws of Washington prohibit the sale of any State lands for less than $10 an acre; therefore the large and increasing area of abandoned lands, except the small portion which may become valuable for farming, must continue to be State property until it can find a purchaser at $10 who is willing to take up the tax burden which could not be borne even when the land was offered for $1. This area must therefore remain absolutely unproductive, nontaxpaying, and, on account of fire, a menace to adjacent standing timber.

So deplorable a state of affairs entails far more than financial loss to the State and its inhabitants. It is generally admitted that the exhaustion of the mature timber of the United States is a matter of but one or two generations, and that thereafter second growth must be used to supply the natural needs. It is the Pacific coast region, with its warm climate and heavy rainfall, which promises the most certain and rapid return of logged-off land to forest, and to this region the country will naturally turn for much of its timber supply in the future. With the exception of the Government forest reserves, no provision is being made to meet this demand, and for this condition of affairs unwise taxation is largely responsible.

Over the larger part of western Oregon and Washington, Red Fir is the tree which takes possession of burned-over land, and, if undisturbed, it does so almost immediately. It is at present the most valuable timber tree of the region, and its readiness to reforest denuded land seems exceedingly fortunate. There are, however, certain regions in which there is practically no reproduction of Fir, and here the market future of Hemlock will fix the profit of growing a second crop. This is largely the case along the coast.

The present practice is to cut all good Fir and Spruce and to leave the Hemlock and only such Fir as is conky or otherwise unsound and hence unable to play an important part in reseeding the lumbered area. (Pl. X, fig. 1.) There is, of course, the adjacent untouched forest, which, under some conditions, would, by the aid of the wind, seed up openings as fast as they might be made by ordinary lumbering; but here the Fir bears irregularly and scantily, and little seed is produced. On the other hand, the Hemlock, which is left untouched in the slashings and forms a large part of the neighboring forest, bears abundantly every year. Furthermore, the slashing may escape fire, in which case Fir seed finds an unsuitable seed bed and is shaded too much by uncut Hemlock and underbrush. The final result under such conditions is a dense stand of Hemlock, often some Spruce, but only occasionally a Red Fir. (Pl. X, fig. 2.)

It is not impossible that this result might often be somewhat modified by judicious burning. While many loggers prefer, if possible, to avoid fire altogether, there are two arguments for a contrary course—safety in the future and a better chance for reproduction of Fir. There remains little doubt that fire after logging greatly assists this

FIG. 1.—LOGGED-OFF LAND, BUCKLEY, WASH. HEMLOCK AND DISEASED FIR LEFT STANDING.

FIG. 2.—HEMLOCK LEFT AFTER LOGGING, ENUMCLAW, WASH., SHOWING STUMPS OF RED FIR.

species to reproduce successfully. If fire is to run, it is usually safer to burn at that time in the spring when the slashing is inflammable but the surrounding woods are still too wet to be in danger than to allow a large area to remain unburned until the dry season, when fire is sure to be destructive.

In the coast region, owing to the frequent rains, the burning of the slashings as a precautionary measure is not so necessary as it is inland. Therefore, before adopting it in order to facilitate the reseeding of Fir, it should be ascertained whether it would not be more profitable to give up Fir altogether and make the most of the Hemlock. To decide this question a careful study of conditions on the ground is necessary. The amount and condition of young Hemlock must be excellent in order to make it worth preserving should there be a chance of obtaining Fir by its removal. (Pl. X, fig. 2.) A few half-grown trees are of little value, for without shade they will not clear themselves of branches. (Pl. X, fig. 1.) An undergrowth of suppressed, misshapen Hemlocks a few feet high, such as is often seen in dense timber, is not apt to make a healthy growth. In fact, the sudden advent of light often destroys Hemlock which has grown in the shade. Where such conditions prevail, and if the Fir in the vicinity can be counted on to reproduce itself upon the logged-off area, it is unprofitable to adopt a method favorable only to Hemlock.

It should be remembered, however, that, where the ground is covered by a foot or more of rotten wood and humus, fire may kill the young Hemlock and still not expose the soil sufficiently to encourage germination of Fir. Even slightly injured Hemlock is worthless, for it is almost certain to be attacked by borers. Blazes, fire scorch, and scars from rigging, in fact, anything which deadens a small portion of the bark, encourages their entrance. Other insects and parasites should also be remembered. In a region where such enemies of Hemlock as black streak, borers, and Arceuthobium are prevalent, it would be wise to destroy a fair growth of Hemlock for the sake of a much younger stand of the more hardy Fir.

To sum up, where Fir is a poor seeder and where it is desirable to prevent fire entirely from the first, there is little use in trying to get anything but Hemlock for a second crop, and in such a case there is nothing to do except to protect the slashing from fire. Where the Fir left standing is vigorous enough to seed freely and a fairly clean burn can be secured, it would often seem the best policy to fire the slashing in the spring. It is the purpose of this report, however, to deal not with Red Fir problems, but with those of regions in which reproduction of Red Fir is impracticable. Assuming, then, that from observation the owner of timber land is satisfied that the second growth will be chiefly of Hemlock, he will naturally wish to know how long it will be before it will produce merchantable timber, what its value will be, and how much it will have cost him. In order to answer these ques-

tions as authoritatively as possible, a study of second-growth Hemlock was made, the results of which are given in the following chapter.

VOLUME AND YIELD, SECOND-GROWTH HEMLOCK.

The study of second-growth Hemlock has so far been confined to the coast region. The results obtained can also be applied with fair accuracy to second growth upon the western slope of the Cascades, where the rainfall is nearly as heavy as it is near the Pacific. The most important localities selected as representative of coast conditions were near South Bend and Willapa, in Pacific County, Wash. The former

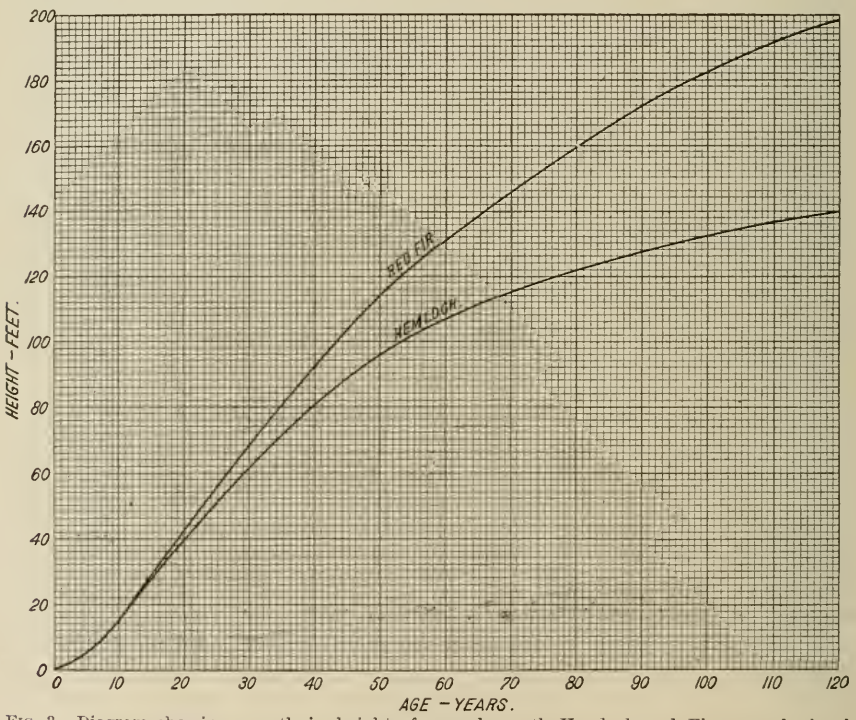

FIG. 3.—Diagram showing growth in height of second-growth Hemlock and Fir, on a basis of diameter breasthigh.

contains a large tract of pure Hemlock, almost uniformly 55 years old (Pl. XI), which formed the basis for the study of pure stands. Near Willapa were found, in addition to a pure stand of Hemlock, a typical mixture of Fir and Hemlock about 75 years old, which illustrated the behavior of the species when growing in mixture. A mixed stand 120 years old was found at Stella, Cowlitz County, on the Columbia, and studies of similar stands were made elsewhere throughout the State.

Although it is not difficult to find sufficient stands of second growth to show what may be expected upon logged-off lands, there is no logging in these stands. In order, therefore, to compute yield tables, it

PURE SECOND-GROWTH HEMLOCK, 55 YEARS OLD, SOUTH BEND, WASH.

was necessary to create an arbitrary standard of merchantable size. It was assumed that in fifty years, the probable shortest time in which land now bare can be logged again with profit, timber will have gained in value sufficiently to warrant the cutting of any tree which will yield a log 20 feet long and 12 inches at the small end. A few of the trees 13 inches in diameter breasthigh will contain such a log, but it was thought safer to take 14 inches as the limit. In the subsequent discussion of second growth, therefore, all trees 14 inches and over are considered merchantable, and it is assumed that all timber between the stump and a point 12 inches in diameter inside the bark will be utilized.

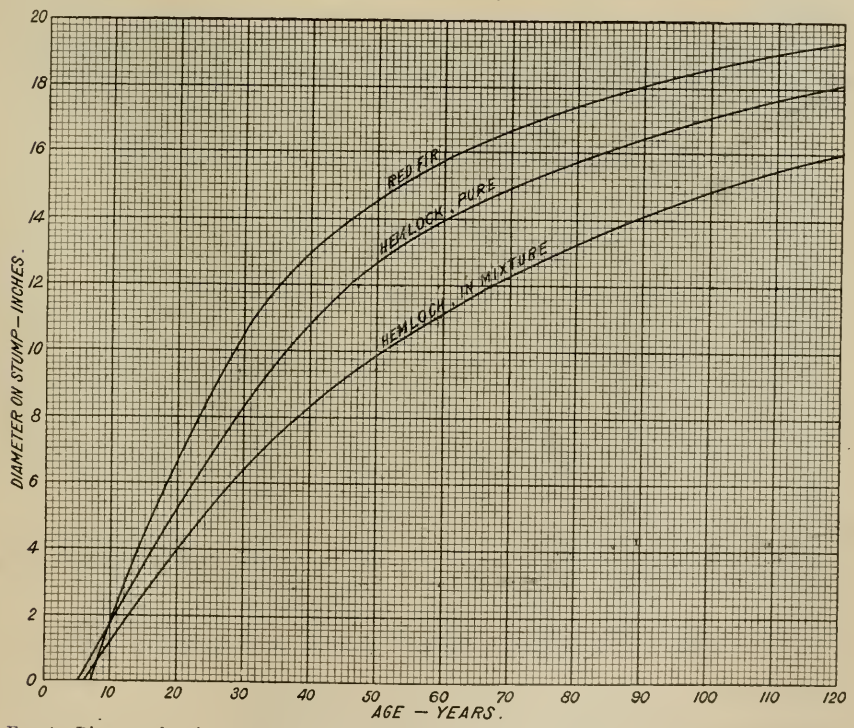

FIG. 4.—Diagram showing growth in diameter of second-growth Red Fir and Hemlock in pure stands and of Hemlock in mixture with Red Fir.

Such material as piling or trap poles will be produced in less than fifty years, but earlier than this the trees will not clear themselves sufficiently to make merchantable sawlogs, even if a few reach the requisite size.

The growth of pure and mixed even-aged forests is very different. In the former, Hemlock grows rapidly, with a normal relation between diameter and height growth. The stand is exceedingly dense at first, and remains so longer than does a Red Fir forest on account of the greater tolerance of the Hemlock. The growth in height and diameter is also slower than that of Red Fir. Where, however,

Hemlock comes in with Fir on denuded land, it is after the first few years influenced by its more rapidly growing rival. The Fir soon overtops it by a few feet, but the ability of Hemlock to live under such conditions prevents it from being shaded out. The result is that the height growth of Hemlock in mixture with Fir is as rapid as that of a pure stand, and that the suppression is shown by a falling off in its diameter growth. Figs. 3 and 4 show graphically the growth of Hemlock and Fir and the growth of the same species, both when in mixture and when in pure stands. These curves represent conditions near the coast, and are somewhat higher than would be an average for the State.

The following two tables give, on a basis of diameter breasthigh, the total height, length of crown, and merchantable length of second-growth Hemlock in mixture with Fir and in a pure stand:

TABLE 13.—*Mixed stands, Hemlock and Red Fir, 75 years old, Willapa.*

Diameter breasthigh.	Total height.	Length of crown.	Merchantable length.
Inches.	*Feet.*	*Feet.*	*Feet.*
14	121	53.0	21
15	127	57.0	27
16	132	60.0	34
17	136	62.0	42
18	139	63.0	51
19	142	64.0	58
20	144	65.0	64
21	145	65.5	69
22	145	66.0	73
23	145	66.0	77
24	145	66.0	80
25	145	66.0	83

TABLE 14.—*Pure stand of Hemlock, 55 years old, South Bend.*

Diameter breasthigh.	Total height.	Length of crown.	Merchantable length.
Inches.	*Feet.*	*Feet.*	*Feet.*
14	107	50	24
15	109	52	29
16	111	53	35
17	113	54	42
18	115	55	48
19	116	56	53
20	117	56	56
21	118	57	59
22	119	57	62
23	120	58	64
24	120	58	66
25	120	58	66

The character of three typical second-growth stands in Washington is shown in Table 15, which is the result of surveys and measurements similar to those made in mature timber and previously described. It will be noted that in Willapa, where the mixture of Hemlock is most uniform, the stand is unusually heavy for its age. This is in part due to the fertility of the soil and a very heavy annual rainfall, but probably also to the composition of the mixture, for a tract of given size can support a heavier forest of mixed Fir and Hemlock than of either species alone. It is evident that, since the future yield of a second crop is influenced by the mixture of species, knowledge of the rate of growth

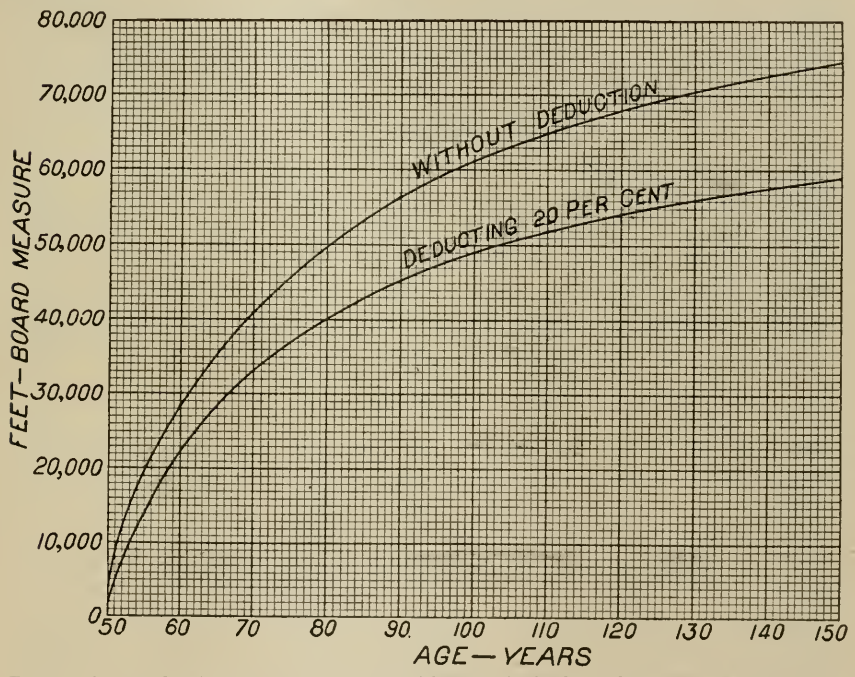

FIG. 5.—Diagram showing yield per acre in board feet on a basis of age of pure even-aged Hemlock, with and without deduction for cull.

will not suffice to foretell it unless the composition of the mixture is known. It is useless, therefore, to make hard and fast tables of future yield for indiscriminate application to the varying growths which may occur after logging. For a pure stand the problem is much simpler. Fig. 5 represents graphically the stand which may be expected from pure even-aged Hemlock near the coast of Washington. It includes second growth only and not those trees which may escape the first cutting. The upper curve shows the yield without allowance for cull; the lower curve, the yield after 20 per cent for dead, diseased, scrubby, or otherwise unmerchantable trees has been deducted.

TABLE 15.—*Stand and yield per acre in typical localities.*

STELLA (120-YEAR OLD STAND).

[Average of 155 acres.]

Species.	Number of trees—		Average diameter of trees—		Yield of trees 14 inches and over in diameter breasthigh.	
	6 inches and over in diameter breast-high.	14 inches and over in diameter breast-high.	14 inches and over in diameter breast-high.	6 to 13 inches in diameter breast-high.	Lumber.	Bark.
			Inches.	*Inches.*	*Board feet.*	*Cords.*
Hemlock	10.8	3.28	20.9	8.0	1,592	0.29
Red Fir	47.1	44.36	28.6	10.9	57,312	.....
Cedar	.7	.28	21.1	9.0	146	.....
Total	58.6	47.92	28.3	8.9	59,050	.25

WILLAPA (90-YEAR OLD STAND).

[Average of 65 acres.]

Hemlock	42.4	13.9	22.1	7.7	8,146	1.64
Red Fir	54.6	45.1	25.5	10.6	39,344	.....
Spruce	13.5	6.7	26.5	8.2	6,430	.....
Cedar	.5	.2	25.3	8.8	140	.....
Total	111.0	65.9	23.9	8.4	54,060	1.46

SOUTH BEND (55-YEAR OLD STAND).

[Average of 131 acres.]

Hemlock	126.3	55.2	19.5	8.4	16,190	4.2
Spruce and Cedar	14.2	7.2	21.7	8.8	2,075	.....
Total	140.5	62.4	20.6	8.6	18,265	3.6

UTILIZATION OF SECOND-GROWTH STANDS.

Assuming that in the future there will be a considerable area of second-growth Hemlock, the question arises, at what age can it be most profitably logged and how shall the forest be perpetuated? This can be discussed only in a general way, for it depends greatly upon the development of Hemlock as a commercial timber and upon the uses to which it is put. The tables in this report show that small sticks, such as are suitable for trap poles, may be cut in forty years, and that in fifty years logs will be produced which would be considered of fair size in the East to-day. In this time, however, according to fig. 5, there will be only a little over 2,000 feet to the acre, which even, allowing a stumpage of $1 per 1,000 feet, is an insignificant amount. Considering it as a fifty-year investment, there will have been a mean annual production of about 40 board feet an acre. At the end of sixty years the stand will be 22,000 feet, or a mean yield of 366 feet. The annual increment increases to 471 feet for a seventy-year period and reaches 500 feet at eighty years. At eighty-five it is but a few feet

more, and from then on it decreases steadily in rate of production. It appears, therefore, that the greatest production of wood can be secured by cutting second-growth Hemlock when it is about 80 years old.

However, there are other points which weigh in the consideration of the cutting age. If it is intended to keep the land perpetually in forest, provision must be made for a third crop, and it will not do to cut at a time when natural reproduction is doubtful. Early in the life of an average second-growth Hemlock stand there are many small trees which gradually become shaded out and killed by their more vigorous neighbors. If no cutting is done before the end of eighty years, most of these will have died and rotted, and if everything down to 14 inches is cut there will be few trees left to form part of a third crop. If the cut is made at sixty years, there will be a good nucleus left for a third crop, but the cut will be small and the timber inferior. The most profitable plan seems to be to wait a few years longer and to trust to natural seeding if a third crop is desired. At first, because of the dense shade, there is little or no reproduction beneath second-growth Hemlock. However, after about sixty years or more, according to the density, the Hemlock bears seed and the gradual thinning out of the stand admits sufficient light for the germination and growth of seedlings. If the forest is cut when 80 years old, many of the seedlings will live, and with those which spring up in the slashing will form sufficient basis for another stand. There will also be many fair-sized trees left standing, some of which, at least, will not be thrown by wind. So far as can be judged at present, the cutting age or rotation of largest yield need not be abandoned in order to insure reproduction.

The rotation of greatest financial profit still remains to be reckoned, for this is not necessarily identical with that of the greatest wood production. It is determined by the period at which the value of the crop represents the highest interest on the capital invested. Owing to the uncertainty of taxation and of the future value of Hemlock stumpage the calculation can only be tentative.

The actual sale value of denuded land in the coast counties of Washington can safely be placed at not over $1 an acre, or $160 for a quarter section. The land will probably be assessed at about $3 an acre and taxed at 2 cents on the dollar, which is 6 cents an acre, or $9.60 for the quarter section.

Were an owner to sell his land for $160 as soon as it was logged, and deposit the money in a savings bank at 3 per cent compound interest, adding annually the sum which he would pay for taxes had he held the land, the total amount to his credit at any given period would represent the cost of holding the land for a second crop during the same time. The calculation of this amount and its comparison with the value of the land and crop is found in Table 16. It illustrates

strikingly the possible loss or profit in holding logged-off land, assuming, of course, that the premises of taxation and stumpage are correct. The table shows that 70 years is the most profitable age at which to cut if stumpage is figured at either 75 cents or $1. At 50 cents the whole transaction is a losing one, and the longer the rotation the greater the loss.

TABLE 16.—*Financial result of cutting one quarter section of Hemlock after 60, 70, and 80 years.*

Time between cuts, or rotation, years.	Value of land and crop at end of rotation.			Proceeds of $9.60 deposited annually, at 3 per cent compound interest.	Gain by holding land.		Loss by holding land, stumpage $0.50.
	Stumpage.				Stumpage.		
	$1.00.	$0.75.	$0.50.		$1.00.	$0.75.	
60	$3,792	$2,884	$1,976	$2,451.40	$1,340.60	$432.60	$475.40
70	5,440	4,120	2,800	3,304.53	2,135.47	815.47	504.53
80	6,560	4,960	3,360	4,681.80	1,878.20	278.20	1,321.80

The largest profit shown above, that of a seventy-year rotation with a selling price of $1 stumpage, represents about 4.5 per cent compound interest upon the investment.

It should be clearly understood that these statements of profit are purely tentative, based upon tax rates and stumpage values which can not be foretold at present. They are believed to be conservative. The individual can, if he desires, make similar calculations upon such premises as seem in his judgment more probably correct.

From the foregoing pages it may be seen that the largest sustained yield is secured by cutting every eighty years, but that the interest on the invested capital which the crop represents is apparently highest at the end of seventy years. There still remains to be reckoned the bearing of age on the quality of the timber. This and many other questions concerning the future of second growth depend much upon circumstances impossible to foresee. It appears now that it will be about seventy-five years before the second crop can be logged to the best advantage. This does not mean that a considerable amount may not be cut earlier. And even if a long rotation is decided upon, earlier thinning would be beneficial if it could be made profitable. The difficulty lies in cutting small quantities and in disposing of small material which, at present at least, has no place in the market except possibly as trap poles.

HEMLOCK LEFT AFTER LUMBERING.

In the calculation of returns from second-growth Hemlock no account has been taken of small trees left standing after the logging of the old stand. If the slashing is burned these will be destroyed; if not, there will be left for a future crop a number which depends upon the character of the virgin forest and upon the intensity and

destructiveness of the lumbering. This number varies so greatly that it is futile to attempt a general estimate of it. It may, however, readily be ascertained on the ground, and the forester, by finding the rate of growth of the trees under the new conditions, can predict either how long it will be before a given amount can again be logged or how much can be cut after a given time.

Large tracts now being logged near Buckley, Elma, and Hoquiam were selected as examples. It was assumed that all trees above 20 inches were cut for logs and everything between 16 and 20 inches went into skids. The number of trees between 4 and 16 inches which would be left on an acre, if care was taken to destroy as few as possible, was estimated, and these were allowed a conservative diameter growth of an inch in five years for the next fifty years. Their contents in board measure (cutting to 14 inches) at the end of twenty-five and fifty years were then computed, and 25 per cent was deducted for trees which might die, blow down, or prove worthless for lumber. The results are here shown:

TABLE 17.—*Yield per acre from Hemlock left in lumbering.*

Locality.	Number of trees between 4 and 16 inches left on acre.	Yield per acre at the end of—	
		Twenty-five years.	Fifty years.
		Board feet.	*Board feet.*
Buckley	80	3,285	14,190
Elma	52	1,640	8,320
Hoquiam	36	1,745	6,875
Average	56	2,223	9,762

Hoquiam shows less than the normal number of trees for that part of the State, because of an insect attack several years ago, which destroyed many young trees. The figures for Buckley are included to produce a fairer average, although, as a matter of fact, this is a region in which Fir reproduction is feasible, and the burning of slashings is probably better policy than the protection of small Hemlock.

Since a few seedlings and a few vigorous trees which were less than 4 inches in diameter at the time of logging will become merchantable in fifty years, the yield will be somewhat more than the 9,762 feet indicated above. The addition on this account will probably bring the total to about 11,000 feet an acre, or 1,760,000 to the quarter section. At $1 a thousand this will be equivalent to a simple interest of 8.9 per cent on an investment of $1 an acre for the land and 6 cents an acre annual tax for fifty years.

The above calculations indicate a larger yield after fifty years than does fig. 5 for seedling second growth alone. Furthermore, the existence

of a few small trees does not preclude the development of a seedling stand also; therefore, the true second crop will consist of both and be greater than either alone. It will not be equivalent to a combination of both, for the ground and light demanded by the trees which are left standing will be denied to the seedlings. The exact manner in which this rivalry will be adjusted depends upon the number of trees left standing, the condition of the ground for germination of seeds, and numerous other factors which require a study of each case before even an approximate estimate is possible. On the other hand, there is no doubt that if a fair stand of Hemlock remains on cut-over land the yield given by fig. 5 will be increased by from 8,000 to 12,000 feet at the end of fifty years and by an indefinite amount after that time. This is assuming a nearly pure Hemlock reproduction. No attempt will be made to discuss Red Fir seedling growth under such conditions, for it is not apt to appear to any important degree unless there has been fire enough to destroy any small Hemlock which survives logging.

If it is desired to utilize small Hemlock in a future cutting, care should be taken not to injure it unnecessarily during logging. Promising trees need not be cut for skids where poor ones will suffice, and it should be borne in mind that scars caused by rigging, especially in setting strap leads, are almost certain to ruin young trees. Many trees ordinarily destroyed might be preserved at no additional expense by careful swamping, yarding, and falling.

BARK.

Although thinner than that of the Eastern species, the bark of the Western Hemlock is exceedingly rich in tannic acid. This has long been known to the trade, and several experiments have been made with a view to the establishment of extract works in the Northwest. A plant was actually started near South Bend, Wash., in 1893, but, owing to insufficient capital, to the general financial depression of the period, and, it is said, to the opposition of Eastern bark interests, it was soon shut down. The promoters claim, however, to have demonstrated the feasibility of a similar enterprise under more favorable conditions. In Oregon, where Hemlock is logged for paper pulp, the bark is utilized by local tanneries and brings from $8 to $12 a cord. The claim is made that it produces a lighter leather than Eastern bark.

So little use is made of the bark that it is difficult, in comparing it with that of the Eastern Hemlock, to determine to what degree its thinness is compensated for by its superior quality. The bark of the Eastern tree averages about 10 per cent tannin. The few available analyses of Washington Hemlock bark vary with locality and through absence of system in selecting samples, but unite in allowing about 16 per cent. Samples collected in Washington by the Division of Forestry

were submitted to the Division of Chemistry of the Department of Agriculture and the following results were obtained:

TABLE 18.—*Analyses of bark of Western Hemlock from Washington.*

	No. 21272. Little Rock, Thurston County.	No. 21273. Ashford, Pierce County.	No. 21274. Enumclaw, King County.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	9.87	10.55	10.01
Total solids	14.32	24.03	22.16
Soluble solids	13.78	22.59	20.58
Reds	.54	1.44	1.58
Nontannins	4.01	6.59	5.72
Available tannins	9.77	16.00	14.86
Woody fiber by difference	75.79	65.42	67.83

In his report upon these analyses Dr. Wiley, Chemist of the Department of Agriculture, says:

Nos. 21273 and 21274 are especially remarkable on account of being so rich in tannin. These barks are all of superior quality, especially the two just mentioned.

These two samples probably represent fairly the bark of the western slope of the Cascades, Enumclaw being about 1,000 feet and Ashford 2,000 feet above sea level. The Little Rock sample is apparently inferior, but can scarcely be regarded as representative, since it was taken from a fallen tree which had been exposed to heavy rains for several weeks. It is not improbable that a fresh sample would have compared favorably with the other two specimens.

In Hide and Leather, of June 24, 1893, appear the results of tests made by H. G. Tabor, manager of the American Extract Works, of Port Allegheny, Pa., which are as follows:

TABLE 19.—*Comparative analyses of Hemlock bark from Washington, Pennsylvania, and Quebec.*

	Washington.	Pennsylvania.	Quebec.
	Per cent.	*Per cent.*	*Per cent.*
Tannic acid	17.04	13.28	10.16
Nontannin	6.40	7.52	4.56
Reds	1.56	3.48	1.92
Wood fibers	75.00	75.72	83.36

Another analysis richer in tannin than either of the preceding was furnished by Professor Fiebing, of Milwaukee, to persons who contemplated starting an extract factory near the coast in southwestern Washington. He found the percentage of tannin in the two samples sent him to be 17.8 and 20.1, respectively. Allowing 2,240 pounds to

the cord, and assuming an average percentage of 10 for Eastern and 16 for Western bark, the quantity of tannin in each would be as follows:

TABLE 20.—*Yield of tannin per cord of Western and Eastern bark.*

	Pounds.
Washington bark	358.4
Eastern bark	224.0
Difference	134.4

VOLUME AND YIELD.

Although the cord is used as a standard of measure for bark, it is usually sold by weight, in order to avoid variation due to loose piling. Throughout the East 2,240 pounds are usually called a cord, although in some places 2,000 pounds are accepted. It was impossible to secure any yield tables based on actual practice in the regions covered by this report; therefore the thickness of bark at various heights was measured on all trees scaled, and the amount in cubic feet produced by the average tree of given diameter, and also by the acre, was computed. These figures were then converted into long and short cords on a basis of 66.6 cubic feet to 2,000 pounds and 77 cubic feet to 2,240 pounds. This was done separately for mature and second-growth timber, assuming that in the latter only the merchantable log length would be peeled, and that in the former all bark would be taken from the stump to a point where the tree is 12 inches in diameter. The following table gives, on a basis of diameter breasthigh, the volume of bark and the number of trees required to make a cord of 2,000 pounds and of 2,240 pounds.

TABLE 21.—*Volume of bark per tree and trees per cord.*

Diameter breast-high.	Cord of 2,000 pounds.		Cord of 2,240 pounds.	
	Bark per tree.	Number of trees per cord.	Bark per tree.	Number of trees per cord.
Inches.	*Cords.*		*Cords.*	
13	0.03	38.5	0.02	45.4
14	.03	33.3	.03	40.0
15	.04	26.4	.03	31.2
16	.05	21.8	.04	25.0
17	.06	17.0	.05	20.0
18	.07	14.1	.06	16.3
19	.09	11.8	.07	13.5
20	.10	9.8	.09	11.3
21	.12	8.3	.10	9.7
22	.14	7.1	.12	8.3
23	.16	6.2	.14	7.2
24	.18	5.5	.16	6.3
25	.21	4.8	.18	5.6
26	.23	4.3	.20	5.0
27	.26	3.9	.22	4.5
28	.29	3.5	.25	4.0
29	.32	3.2	.27	3.6

TABLE 21.—*Volume of bark per tree and trees per cord*—Continued.

Diameter breast-high.	Cord of 2,000 pounds.		Cord of 2,240 pounds.	
	Bark per tree.	Number of trees per cord.	Bark per tree.	Number of trees per cord.
Inches.	*Cords.*		*Cords.*	
30	0.25	2.9	0.30	3.3
31	.38	2.7	.33	3.1
32	.41	2.5	.35	2.8
33	.44	2.3	.38	2.6
34	.47	2.1	.41	2.4
35	.51	2.0	.44	2.3
36	.54	1.9	.47	2.1
37	.58	1.7	.50	2.0
38	.61	1.6	.53	1.9
39	.65	1.6	.56	1.8
40	.68	1.5	.59	1.7
41	.72	1.4	.62	1.6
42	.76	1.3	.66	1.5
43	.80	1.3	.69	1.4
44	.84	1.2	.73	1.4
45	.88	1.1	.76	1.3
46	.92	1.1	.80	1.3
47	.97	1.0	.84	1.2
48	1.01	1.0	.87	1.1
49	1.05	1.0	.91	1.1
50	1.10	.9	.95	1.1

Where bark is peeled from trees cut for lumber it is frequently the custom to reckon the yield by the amount produced to the thousand feet of logs, board measure. In the East half a cord to the thousand is considered a fair average, and is equivalent to about 112 pounds of tannic acid. On the Pacific coast the thinness of the bark and less economical logging practices unite to reduce this proportion, and a quarter of a cord to the thousand is all that can be relied on, but this will average 90 pounds of tannin. The yield per acre is necessarily exceedingly variable. For example, Table 11 represents regions where Hemlock forms a given per cent of the total stand of mature timber. Table 16 is for second growth. No figures were obtained for pure, mature Hemlock. The examples given compare favorably with the yield of pure Hemlock land in the East, where the best seldom exceeds 20 cords an acre and the average is about 5. Good authorities place the average crop for Pennsylvania at 7½ cords, for New York 4, and for Maine only 3 cords per acre. Taking a pure 55-year-old stand at South Bend, Wash., as a basis, together with cruisings and measurements in other young timber, it has been possible to figure with approximate accuracy the yield which may be expected from an average well-stocked acre of pure young Hemlock at a given age. The results are shown in Table 22. Only trees 14 inches and over in diameter breasthigh have been considered, and these peeled to a point 12 inches in diameter in the tops.

TABLE 22.—*Yield of bark per acre from pure second-growth Hemlock.*

	Age of stand.							
	50 years.	60 years.	70 years.	80 years.	90 years.	100 years.	110 years.	120 years.
	Cords.	*Cords.*	*Cords.*	*Cords.*	*Cords.*	*Cords.*	*Cords.*	*Cords.*
Allowing 2,000 pounds to 1 cord....	2.5	6.8	9.2	10.1	11.5	12.1	12.3	12.9
Allowing 2,240 pounds to 1 cord....	2.2	5.9	7.9	9.1	9.9	10.4	10.8	11.1

Toward the upper limit of the Hemlock, seldom below 2,400 feet above sea level, its bark often strikingly differs from that of the tree at lower elevations. It is exceedingly thick, often 2 inches, and is deeply furrowed. (See Pl. XII.) No volume or yield tables were made for this upland form, but it is probable that trees would contain twice as much bark as those of corresponding size at lower elevations.

HARVESTING.

In the East, where the methods of harvesting bark have developed into an established process, the usual peeling season extends from May to August, although the bark peels easiest from the first of June to the middle of July. Where bark alone is the object, a peeling crew consists of three men—faller, fitter, and spudder; but where the cutting is primarily for lumber, the first might be considered one of the logging crew. The fitter trims off branches, rings the bark at intervals of 4 feet, and slits each section lengthwise. The spudder peels the bark with a flattened bar and spreads it on the ground with the flesh, or inner side, up. After it has cured in the sun for five to ten days it is carefully piled, exterior side uppermost, to complete the seasoning process, which, unless the season is wet or the bark is piled in a shady place, requires but two or three months. It is highly desirable to remove the bark from the woods as soon as it is seasoned, for if left until winter it becomes covered with snow and ice, loses a considerable part of its tanning property, and curls badly; but in regions where roads are bad in summer it is often left to be taken out on sleds after snowfall.

It is evident that the wet climate of Oregon and Washington will prove somewhat detrimental to the economic handling of bark. Unfortunately, the heaviest rain occurs in the Hemlock regions. The thinness of the bark, the greater care required to cure properly, and the higher price of labor will tend to make the cost of production per cord greater than it is in the East. On the other hand, Hemlock stumpage is low, the bark is richer, and, since the roads are best in the fall, there need be no difficulty in getting it out when it is in the best condition.

FIG. 1.—WESTERN HEMLOCK, CASCADE MOUNTAINS, WASHINGTON. ALTITUDE, 2,500 FEET, SHOWING THICK, ROUGH BARK OF MOUNTAIN FORM.

FIG. 2.—WESTERN HEMLOCK, CASCADE MOUNTAINS, WASHINGTON. ALTITUDE, 3,000 FEET, SHOWING THICK, ROUGH BARK OF MOUNTAIN FORM.

On its arrival at the works the bark usually contains from 8 to 12 per cent of water. Fresh bark does not yield the acid readily. Hence when possible it is stored until fully cured, usually between one and two years. It is highly important to keep it well protected from rain, for it leaches easily and is soon ruined. For the same reason, bark from logs which have been towed or driven is of little value. Salt water ruins it entirely. If well cared for, nearly all the tannin in the bark is available. A cord of Eastern bark yields from 400 to 430 pounds of extract, which is sufficient to tan from 200 to 225 pounds of sole leather, or a trifle more of upper leather.

At present the available supply of hides in the Pacific Northwest is insufficient to support a tanning industry of any great proportions. It is probable that before there is a home market for any considerable quantity of bark it will be required to supply tanneries in the East, where complaint is already made of an inadequate supply. If this proves true, the product must be shipped in a condensed form and considerable capital will be required to develop the industry.

EXTRACT.

The process of making the extract is as follows: The bark is ground and placed in wooden vats, where it is steeped until the acids are removed. The resulting liquor is then evaporated in a vacuum at a temperature of about 180° F. until it is reduced to a heavy, dark colored fluid weighing about 10 pounds to the gallon and containing nearly all the tanning properties of the bark. Assuming the unsteeped bark to have 10 per cent of tannic acid, 100 pounds of it would produce about 40 gallons of 20° liquor, which, upon analysis, would show about 2½ per cent of tannin. The extract is usually shipped in 500-pound barrels and brings about 2½ cents a pound.

While the production of ground tan bark for local use is a simple process, the successful manufacture of extract requires even more expensive machinery than the manufacture of lumber. In the East, where machinery is cheaper than on the Pacific coast, a 10-barrel plant costs from $15,000 to $20,000. The leach house is much like that of a tannery, but an evaporating plant is also required in which all vats and pipes must be copper or brass lined, and this part of the establishment represents a large proportion of the entire expense. It is also customary to conduct a barrel factory in connection with the plant. From these considerations, it is apparent that extract works will be built only where there is certainty of a sustained bark supply and that, owing to the cost of transportation, Hemlock will probably be more valuable where it occurs in sufficient quantity to support a factory than in regions where the bark must be sent a distance to market.

A LIST OF THE TREES OF OREGON AND WASHINGTON, WITH SOME IMPORTANT SHRUBS.

Common name.	Scientific name.	Where found.
Sugar Pine	*Pinus lambertiana* Dougl	Oregon only.
Western White Pine	*Pinus monticola* Dougl	Semi-Alpine.
White-bark Pine	*Pinus albicaulis* Engelm	Alpine.
Bull or Yellow Pine	*Pinus ponderosa* Laws	
Jeffrey Pine	*Pinus jeffreyi* "Oreg. Com."	Oregon only.
Scrub Pine	*Pinus contorta* Loud	
Lodgepole Pine	*Pinus murrayana* "Oreg. Com."	
Knobcone Pine	*Pinus attenuata* Lemmon	Do.
Tamarack or Larch	*Larix occidentalis* Nutt	
Sitka or Tideland Spruce	*Picea sitchensis* (Bong.) Trautv. & Mayer.	
Engelmann Spruce	*Picea engelmanni* Engelm	Do.
Brewer Spruce	*Picea breweriana* Wats	Do.
Western Hemlock	*Tsuga heterophylla* (Raf.) Sargent	
Black or Alpine Hemlock	*Tsuga mertensiana* (Bong.) Carr	Alpine.
Red or Douglas Fir	*Pseudotsuga taxifolia* (Lam.) Britton	
White or Balsam Fir	*Abies grandis* Lindl	
White Fir	*Abies concolor* (Gord.) Parry	Oregon only.
Shasta Fir	*Abies shastensis* Lemmon	Do.
Alpine Fir	*Abies lasiocarpa* (Hook.) Nutt	Alpine.
Amabilis Fir or, erroneously, "Larch"	*Abies amabilis* (Loud.) Forb	Semi-Alpine.
Noble Fir or, erroneously, "Larch,"	*Abies nobilis* Lindl	Do.
Red Cedar or Giant Arborvitæ	*Thuja plicata* Don	
Alaska Cedar	*Chamæcyparis nootkatensis* (Lamb.)Spach.	Do.
Port Orford Cedar	*Chamæcyparis lawsoniana* (Murr.) Parl	Oregon only.
Incense Cedar	*Libocedrus decurrens* Torr	Do.
Redwood	*Sequoia sempervirens* (Lamb.) Endl	Do.
Juniper	*Juniperus scopulorum* Sargent and *J. occidentalis* Hook.	
Yew	*Taxus brevifolia* Nutt	
Willow	*Salix* (several species)	
Aspen	*Populus tremuloides* Michx	
Cottonwood	*Populus trichocarpa* Torr. & Gr	
Balm of Gilead	*Populus balsamifera* Linn	Do.
Paper Birch	*Betula papyrifera* Marsh	Washington only; very rare.
Western Birch	*Betula occidentalis* Hook	Rare.
Red Alder	*Alnus oregona* Nutt	
Mountain Alder	*Alnus viridis* De C	
White Alder	*Alnus rhombifolia* Nutt	
Western White or Prairie Oak	*Quercus garryana* Dougl	
Canyon Live Oak	*Quercus chrysolepis* Liebm	Oregon only.
California Black Oak	*Quercus californica* (Torr.) Coop	Do.
Tanbark Oak	*Quercus densiflora* Hook. & Arn	Do.
Wild Crabapple	*Pyrus rivularis* Dougl	
Black Haw	*Crataegus douglassii* Lindl	
Wild Cherry	*Prunus emarginata* (Dougl.) Walp	
Wild Plum	*Prunus subcordata* Benth	Do.
Bigleaved Maple	*Acer macrophyllum* Pursh	
Vine Maple	*Acer circinatum* Pursh	
Dwarf or Mountain Maple	*Acer glabrum* Torr	
Dogwood	*Cornus nuttallii* Aud	
Madrone	*Arbutus menziesii* Pursh	
Oregon Ash	*Fraxinus oregona* Nutt	
California Laurel	*Umbellularia californica* (Hook. & Arn.) Nutt.	Do.
Elderberry	*Sambucus glauca* Nutt	Chiefly in burns.

A list of the trees of Oregon and Washington, with some important shrubs—Continued.

SHRUBS.

Common name.	Scientific name.	Where found.
Salal	*Gaultheria shallon* Pursch	
Oregon Grape	*Berberis nervosa* and *B. aquifolium* Pursch.	
Salmonberry	*Rubus spectabilis* Pursch	
Devil Club	*Fatsia horrida* Benth. & Hook	
Red Huckleberry	*Vaccinium parvifolium* Smith	
Blue Huckleberry	*Vaccinium ovalifolium* Smith	
Wild Spiræa or Arrow-wood	*Spiræa discolor* Pursch	
Goat Brush, Buck Brush, or Wild Box	*Pachystima myrsinites* Raf	Semi-Alpine.
Manzanita	*Arctostaphylos tomentosa* Dougl	
Serviceberry	*Amelanchier alnifolia* Nutt	In burns.

In burns and open ground the plants of most importance are the common Fern or Brake (*Pteris aquilina* Linn), Blackberry (*Rubus ursinus* Cham. & Schlecht), Thimbleberry (*Rubus nutkanus* Mocino), and Fireweed (*Epilobium spicatum* Lam.).

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF FORESTRY—BULLETIN 34.

GIFFORD PINCHOT, Forester.

A

HISTORY OF THE LUMBER INDUSTRY

IN THE

STATE OF NEW YORK.

BY

WILLIAM F. FOX.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

BUREAU OF FORESTRY.

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AN ADIRONDACK LOGGING CAMP.

U. S. DEPARTMENT OF AGRICULTURE.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Forestry,
Washington, D. C., April 30, 1903.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 34 of the Bureau of Forestry, a report entitled, "A History of the Lumber Industry in the State of New York," prepared by Col. William F. Fox, superintendent of forests in that State and a collaborator of this Bureau. Colonel Fox is fitted both by study and by experience as a lumberman to treat his subject authoritatively. The historical matter this report contains is now made readily accessible for the first time.

Very respectfully,

Gifford Pinchot.
Forester.

Hon. James Wilson,
Secretary of Agriculture.

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A HISTORY OF THE LUMBER INDUSTRY IN THE STATE OF NEW YORK.

INTRODUCTION.

From the time when the pioneers first swung their axes in the primeval forests of New York, lumbermen have been closely connected with the industrial progress and development of the State. The first settler was the first lumberman; and his work commenced when he felled the trees to make a clearing in the forest for his cabin and his crops. Although this use of the ax alone would hardly constitute lumbering as understood to-day, still it was not many years until a sawmill appeared in each settlement and the lumber industry was formally inaugurated.

Of necessity, the first colonists went without sawmills longer than the later ones. They made rough lumber for their houses, barns, and fences with their axes, supplemented at times by saws, large and small, worked by hand-power. But in the later settlements, which in the beginning of the last century included three-fourths of the State, a sawmill was built in each locality within ten or fifteen years after the first family moved in. In many instances the sawmill preceded the gristmill; and in a few places the erection of the mill antedated the advent of the first settlers.

Whatever means the first colonists used in converting trees into lumber, the methods of logging must have been substantially the same as those of to-day. From the first settlements to the present time lumbermen have never resorted to "clearing" operations in carrying on their New York work. There is, however, a widespread impression to the contrary, and people are very apt to attribute the absence of forests to the work of the lumbermen. This is an error. The disappearance of the forest is due to the farmer, not to the lumberman. In clearing his land the farmer cuts and burns every tree and bush for the purpose of improving his land. The lumberman takes only a few scattered trees to the acre, confining his selection to some merchantable species. The carelessness of the farmers in burning their brush and log heaps has caused many of the fires that have destroyed so much of our forests. Lumbermen do not start fires for their work. The

cutting and skidding are mostly done in the late fall, and the log-hauling in the winter, when the woods will not take fire. Had no other industry but lumbering been carried on within our borders, the once unbroken forests of New York would still be standing.

THE PRIMITIVE FOREST: ITS COMPOSITION.

In 1614, the year when the first houses were built at Albany and on Manhattan Island, the territory which now constitutes the State of New York was forest-covered throughout. Some Indian tribes belonging to the Six Nations had cleared small areas near their villages, on which they raised corn; and, on the east side of the Hudson River, were some openings caused by forest fires which the red men had started in order to facilitate hunting. But these clearings formed an insignificant portion of the entire region. It was a silent, unbroken wilderness—a primeval forest, which in grandeur and undeveloped wealth was unsurpassed in all the region of the Atlantic coast.

New York was not only a forest State, but essentially a white-pine State. This valuable species was plentiful throughout the territory. It was conspicuous everywhere by its towering size, although not as abundant as some of the inferior and smaller associated species. In height, diameter, and quality of timber the pines of New York compared favorably with those of any other region on the continent. The height ranged from 130 to 160 feet, with a diameter, breasthigh, between 2 and 4 feet. In some localities there were individuals of still greater size. Occasional trees are said to have been 255 feet high and about 80 inches in diameter. There is record of a White Pine cut in the town of Meredith, Delaware County, that measured 247 feet in length as it lay on the ground. Many New York lumbermen still living recall giant White Pines that measured 7 feet or more across the stumps and over 220 feet in height.

There is ample historical evidence of the uniform distribution of this species throughout the State. The history of Delaware County states that "the town of Walton when first settled was heavily timbered with pine and some hemlock, which at an early day was rafted to Philadelphia in lumber or logs, constituting the all-absorbing industry from which the land debts and living expenses were paid," and that "the mountain east of the village of Walton received its name from the immense pines that covered its sides, and the entire valley of the village was a dense forest of the same." The history of Cattaraugus County tells of the "remarkable size and good quality" of the White Pine in the southwestern part of New York. Holden's History of Warren County mentions "the splendid pines with which the great Brant Lake tract abounded." The writer—whose grandfather and father were the pioneer lumbermen of that famous tract—well remembers hearing in his boyhood the White Pine of that region enthusiastically described as being "clear as a hound's tooth." The meaning of the Indian name

Schenectady, "the end of the pine plains," indicates that this species was conspicuous in that region, although it seems that there it was largely mixed with Pitch Pine. We are told that Pine street in New York City took its name from the "many magnificent pines" that adorned the farm of Jan Jansen Damen.[a]

Peter Kalm, the Swedish naturalist, who visited Albany in 1749, writes: "The White Pine is found abundant here. The greater part of the merchants have extensive estates in the country and a great deal of wood. If their estates have a little brook, they do not fail to erect a sawmill upon it for sawing boards and planks, with which commodity many yachts go during the summer to New York, having scarce any other lading than boards. They saw a vast quantity of deal from the White Pine on this side of Albany, which is exported."

The younger Michaux states that in 1801 "the shores of Lake Champlain appeared to be most abundantly peopled with this species."

Dr. Torrey wrote in 1843: "The White Pine is found in most parts of the State;" and further, "Our chief extensive forests of this noble and most valuable tree" are "on the headwaters of the Hudson and on the rivers which empty into the St. Lawrence; on the Salmon and Black rivers, which empty into Lake Ontario; on the headwaters of the Delaware and Susquehanna, and on the headwaters of the Allegheny and Genesee." This distribution includes substantially the entire State except the lowlands, from which the White Pine had been taken by the early settlers long before Torrey wrote.

The Adirondack tourist of to-day can still see in the tall trees at Paul Smith's, or in the noble colonnade of White Pine along the shores of Forked Lake, further evidence of its extensive habitat.

The Catskill region was also rich in White Pine, with a strong admixture of Hemlock on its mountainous slopes. The Ulster County Gazette contains an advertisement, dated November 13, 1799, which reads as follows:

FOR SALE.

The one-half of a

SAWMILL

With a convenient place for building, lying in the town of Rochester.[b] By the Mill is an inexhaustible quantity of PINE WOOD.

* * * * * *

Any person inclined to purchase may know the particulars by applying to

JOHN SCHOOMAKER, Jun.

---

[a] New York Historic Trees. New York Times, May 12, 1901.

[b] Town of Rochester, Ulster County; not the city of that name.

The advertiser and his fellow lumbermen of that region have long since gone their way, and with them their "inexhaustible quantity of Pine Wood."

With the White Pine there was in many localities an admixture of Norway Pine; and in Steuben County, or along the southern border, considerable Shortleaf Pine (*Pinus echinata* Mill.), known in that locality as Yellow Pine.

The White Pine, being the most valuable of all the forest trees, was taken first, and, until 1850 or thereabouts, lumbering was confined almost exclusively to this species.

Next in importance atthat time was the Hemlock, which was likewise distributed over the whole territory. Though of inferior dimensions and quality throughout the Adirondack region, in the southern tier of counties and along the Catskill Range it attained a size and strength that compared favorably with the best Pennsylvania Hemlock.[a] But, for a long period, it had no value except for tan bark. The trees were cut and peeled, and the bark hauled to the tanneries; the fallen tree trunks were left in the woods to decay. This was largely the case until within twenty-five years, especially in Pennsylvania, the demand for bark being greatly in excess of the demand for hemlock lumber. Not until there was a scarcity of spruce and pine did lumbermen find it profitable to cut Hemlock for market, and then for many years the margin of profit was very small.

The spruce, which in late years has formed so large a part of our lumber product, was confined mostly to the Adirondack plateau and Catskill slopes. It was not generally found in the western or southwestern portions of the State, nor in the southern tier of counties along the Pennsylvania line, west of Broome County.

The other evergreen species of the State were not extensively used for lumber until quite recently. The Balsam, which is confined chiefly to the Adirondack forests, is now used for lumber and also for pulpwood in a certain percentage of mixture with spruce. The White Cedar has a steady demand, where accessible, for the manufacture of shingles, fence posts, and telegraph poles.

The hardwoods, or broadleafed trees, were everywhere mixed more or less with the evergreens. In some places within the primeval forests there were "hardwood ridges," so called because there were no other species; and in other places there were slopes on which pine,

[a] In the town of Colchester, Delaware County, there is a Hemlock tree over 2 feet in diameter standing on the line between divisions 63 and 64, upon the north side of the hill, opposite the schoolhouse in the Wilson Hollow. In 1535, while it was a young tree about 6 inches through, it was marked by some sharp instrument, probably an Indian weapon. Two hundred and fifty-three annual rings of growth over this mark is a blaze made by James Cockburn in 1788, and over another twenty-eight annual rings is a blaze made by Christopher Tappen in 1816.

Hemlock, or spruce grew unmixed in pure stands or "clumps." Along the river valleys where the soil was rich and dark with alluvial deposits, the more valuable hardwoods—White Oak, White Ash, Black Cherry, and Black Walnut—predominated. Maple, Beech, and birch grew everywhere, on mountain and plain; but there was no Chestnut or oak on the great northern plateau, and there is none there now.

Until recent years lumbermen paid but little attention to the hardwoods, and but few were cut except for cooperage, furniture, or pyroligneous acid—industries which until quite recently were never prominent in this State.

As fast as the lumbermen took out the pine and Hemlock, however, the great hardwood forests that remained fell beneath the axes of advancing farmers, and disappeared in fire and smoke.

BEGINNINGS OF LUMBERING.

The evolution of the sawmill is largely due to the conditions and demands of the lumber industry in America. Our early colonists built and operated sawmills one hundred years or more before there was one in England. This method of manufacturing was not, however, absolutely necessary. The wainscotings, paneled ceilings, cabinetwork, and Chippendale furniture which made famous the stately homes of England were constructed in all their perfection long before the first sawmill was erected in that country. The men who founded the Massachusetts Bay Colony, together with the emigrants who followed them for a hundred years, had never seen a sawmill in their native land. So, if a sawmill did not always appear in a colony soon after the first settlement, it does not follow that no lumbering was carried on. They had other means of manufacturing the forest products.

The pioneer of the wilderness, with ax and wedge, could easily supply his few wants in this respect; but in the villages which sprang up at each important trading post there was a demand for building material and ship-timber which the villagers themselves could not well supply. Most of them were engaged in better paying pursuits or professions; hence, some labor found employment in manufacturing lumber by hand-power. The large timbers for house and ship building were hewn out and squared with a broadax by men who were experts with this tool. The planks, boards, and boat sides were mostly made by pit-sawing. The latter was a common industry in the old country; and one reason why England had no sawmills until after 1768 was because the mobs, always opposed to labor-saving machinery, destroyed the first ones as fast as erected through fear that the pit-sawyers would be thrown out of employment.

PIT-SAWING.

Pit-sawing was done by two men with a long saw that had cross handles on each end. A stick of timber, hewed square, was placed over a pit, or elevated on trestles. One man stood on top of it and pulled the saw up, and one man stood in the pit below to pull the saw down. (Pl. I.) The workman on top, who guided the saw along the chalk line, and who was supposedly the better man, was called the top-sawyer. The one below was called the pit-man. When sawmills were first substituted in this work the saw was held taut on the upward stroke by a spring pole overhead, and was worked up and down by a wooden beam attached to a crank on the mill wheel. This wooden beam was called the pitman, and is still known by that name in every sawmill throughout the country. Pit-sawing or whip-sawing, as it is often called, was not entirely abandoned on the introduction of sawmills. This old method was still useful in sawing long stuff, because in many mills the log-carriage was not long enough to saw planks of the desired length. As late as 1860, at the gang-mills near Painted Post, Steuben County, the writer saw a large, square stick of timber being sawed in this fashion into long planks for the sides of a canal boat.

THE FIRST SAWMILLS.

John Verrazzano and Hendrick Hudson made their famous discoveries and sailed away without leaving a man behind to occupy the newly found territory. No settlement was made by white men, no house erected, until 1614. Just when the labor of the settlers first took the form which we now call lumbering it is impossible to say, but in 1623, nine years after the first house was built at New Amsterdam, three sawmills were erected there by the Dutch West India Company; and, with their erection, commences the history of lumbering in the State of New York.

The machinery for these mills, which was shipped from Holland, was constructed to run by water-power or by windmill. One of them was built on Governors Island, and was probably operated by wind-power; another, which stood on Sawmill Creek, a tributary of the East River, may have used a water-wheel. In 1639 the mill on Governors Island was leased at an annual rental of 500 merchantable boards, half oak and half pine.

About the same time, perhaps a little earlier, some sawmills were built at Fort Orange (Albany) or in its immediate vicinity. Andries Corstiaensen, a master millwright, with two sawyers, was sent there from Holland in 1630. Among the settlers at Rensselaerwyck (Troy), in 1630, were Lawrens Lawrenssen and Barent Tomassen, sawyers.[a]

[a] History of Albany County, by George R. Howell. New York: W. W. Munsell & Co. 1886.

PIT-SAWING.

Bul. 34, Bureau of Forestry, U. S. Dept. of Agriculture.

FIG. 1.—AN OLD-FASHIONED MILL, SHOWING GUIDE BLOCKS.

FIG. 2.—MILL IN ULSTER COUNTY, SHOWING SAW GATE. OLDEST MILL IN THE STATE, BUILT IN 1803.

AN OLD OVERSHOT WATER WHEEL.

In 1636 Barent Pieterse Koeymans joined the colony, and in the fall of 1645 took charge of the Patroon's sawmills, being allowed 150 guilders a year for board and 3 stuyvers for every plank he sawed. In two years this mill cut over 4,000 boards. In 1673 Koeymans bought a large tract of land on the Hudson River, 12 miles south of Albany (the location of the present town of Coeymans), on which there were some desirable mill-sites, and where Cruyn Cornelissen and Hans Jansen had erected sawmills as early as 1651.

The colonists soon made other settlements in the Hudson Valley, and in 1661 Frans Pieters Clavers built a sawmill on the little stream which runs into the river 2 miles north of Stuyvesant Landing, in what is now the town of Kinderhook, Columbia County. This stream has been known as the Saw Kill ever since. In 1663 a sawmill was built by Jan Barentsen Wemp on the Poesten Kill, a stream which empties into the Hudson at Troy. As the falls of the Poesten Kill (Puffing or Foaming Creek) furnished a strong water-power, it may be assumed that this mill was driven by a water-wheel.

In a letter to the Lords of Trade, England, dated January 2, 1701, the Earl of Bellomont says:[a]

> They have got about 40 sawmills up in this province [the province of New York] which I hear rids more woods or destroys more timber than all the sawmills in New Hampshire. Four saws are the most in New Hampshire that work in one mill, and here is a Dutchman, lately come over, who is an extraordinary artist at those mills. Mr. Livingston told me this last summer he had made him a mill that went with 12 saws. A few such mills will quickly destroy all the woods in the province at a reasonable distance from them.

For the first two hundred years the mills were of rude construction and of small capacity, being limited to a single upright saw. At first the saw was attached directly to the pitman, the blade being steadied by a side pressure from guide blocks. (Pl. II, fig. 1.) Then an improvement was made by straining the saw between stirrups in a frame or "gate," the pitman being attached to the latter. (Pl. II, fig. 2.) As the turbine was then unknown, power was obtained from a single overshot water-wheel. (Pl. III.)

Many of the first sawmills were built in combination with gristmills, often under the same roof, the power being used to drive them both or singly, as needed.

For the next hundred years after the founding of the colonies at New Amsterdam and Fort Orange (Albany) the settlement of the State was confined to the region of the Hudson and Mohawk valleys. The development of the country and growth of the lumber industry were slow compared with the progress which succeeded the Revolution. There being no means of transportation except in the river districts, the lumbermen, after supplying local demands, had to depend on the

[a] Colonial Documents, Vol. III, p. 825.

export business, which was confined largely to the English trade. There was a market for large white-pine masts and ship-timber, which gave employment to axmen and raftsmen to some extent. But even at the close of the Revolution four-fifths of the State was still an unbroken wilderness, and where the large and populous city of Rochester now stands there was not a house or a white man to be seen one hundred years ago.

Except in the Hudson and Mohawk counties settlements and lumbering operations were not commenced earlier than one hundred and twenty-five years ago, while throughout a very large area nothing was attempted until a much later date. (See Appendix and map.) But it is interesting to notice, as at New Amsterdam, how soon the sawmill everywhere followed the first cabin, how quickly the lumber industry began in each pioneer settlement, and how closely it was associated with the development of the country.

THE FIRST LUMBER SHIPMENTS.

The lumbermen of the New Amsterdam colony were not confined to the home market afforded by their fast growing town. They shipped part of their product to England, for at that time, there being no sawmills in Great Britain, all of the lumber used in that country was brought from Holland or made by hand sawyers at home. In fact, the colonists sent some lumber to Holland in 1626, three years after the first shipload of immigrants arrived. At first it was their only article of export besides furs. This consignment in 1626 consisted of "considerable oak timber and hickory," and was sent over in the good ship *Arms of Amsterdam*.

In 1675 the ship *Castle* carried a cargo of timber, valued at £400, from New York to England.

In 1686 Governor Dongan, in a report to the home government, offers to "send over boards of what dimensions you please," adding "three-inch planks for the batteries cost me fifteen shillings the hundred feet." Surely the lumbermen of New York belong to an honorable as well as ancient guild.

THE LUMBER MARKET A CENTURY AGO.

In 1801, according to the younger Michaux, the White Pine that was cut along the shores of Lake Champlain was carried to Quebec by the Sorel and St. Lawrence rivers. He further says:

> What is furnished by the southern part of the lake is sawn at Skenesborough,[a] transported seventy miles in the winter on sledges to Albany; and, with all the lumber of North River, brought down in the spring to New York in sloops of 80 or 100 tons, to be afterwards exported in great part to Europe, the West Indies, and the Southern States.

[a] Whitehall.

The same author, in writing about the lumber market at that time, says:

The White Pine is found there in the following forms: In square pieces from 12 to 25 feet long, and of different diameters; in *scantling*, or square pieces 6 inches in diameter for the lighter part of frames; and in boards, which are divided into *merchantable* or common, and into clear or picked[a] boards. The merchantable boards are three-fourths of an inch thick, from 10 to 15 inches wide, from 10 to 15 feet long, and frequently deformed with knots; at New York they are called Albany boards, and are sold at the same price as at Boston. The clear boards, formed from the largest stocks of the Pumpkin Pines, are of the same length and thickness as the first, and 20, 24, and 30 inches wide. They should be perfectly *clear*, but they are admitted if they have only two knots small enough to be covered with the thumb. This wood is also formed into *clapboards* and *shingles*.

PRIMITIVE METHODS.

At the beginning of the last century there was a lack of the tools and labor-saving appliances which are considered indispensable to-day in the lumber business. Even the ax of the chopper was homemade—a single bit with a curved hickory handle, the rude handiwork of the nearest blacksmith; for the ax factories were yet to come, and the double-bitted ax had not been invented. Crosscut saws, which had to be imported from England, were scarce and costly; hence the tree trunks were cut into logs by chopping instead of sawing. The millwrights were not much better off for tools. The first mill in Rensselaer County was built in 1792, by a man named Cross, who "had no tools but an ax, saw, and auger."

Skidways were rarely made, except where a stock of logs was left lying in the woods, the logs being usually hauled directly to the mill. Oxen were used for the most part in logging, the same teams being employed on farm work part of the year; for the lumberman was also a farmer.

There was no river-driving then. The great White Pines stood close around the mill itself, and so thickly that the logs were quickly and easily "snaked" there. The old-fashioned one-saw mill did not require much timber to stock it; hence several years would elapse before the haul became too long to be profitable. Then the lumberman would move his mill into another tract of timber and resume logging. It was not until years later that the Fox Brothers, the pioneer lumbermen of Warren County, conceived the plan of driving the logs to the mill instead of moving the mill to the logs, and so sent the first log drive down the Schroon River branch of the Upper Hudson.

There were timber thieves in those old days as well as now. Mr.

[a] "Pickings" still forms one of the well-known grades made by the lumber inspectors in the Albany market.

Nathan Ford, the pioneer of Ogdensburg, in a letter to Samuel Ogden, December 27, 1799, wrote:

> There are several persons now cutting timber upon the two upper townships. Mr. Wilkins took down the names of several who pretended to settle; their motive was only stealing off the timber. If something is not done about this business, great destruction will arise. An example ought to be made, and this can not be done without sending an officer from Fort Stanwix. They have got the timber so boldly that they say there is no law that can be executed upon them here.

But if there were thieves, there were likewise foresters to look after them. In 1770 Adolphus Benzel, son of Archbishop Eric Benzel, of Sweden, was appointed inspector of His Majesty's woods and forests in the vicinity of Lake Champlain, at a salary of £300 per annum. His residence was at Crown Point.[a] As early as 1700, Lord Bellomont, governor of New York, recommended that each person who removed a tree should pay for planting "four or five young trees;" that no tree should be cut "that is marked for the use of the Navy," and that no tree or trees be cut "but when the sap is in the root."[b]

A DANGEROUS LIFE.

The life of the pioneer woodsmen was always beset with dangers peculiar to their work. Early town records make frequent mention of fatal accidents which befell them. It is remarkable how often the first death in a settlement was of some man killed by a falling tree,[c] of one who was crushed by a load of logs, or killed in his sawmill. Not only the pioneers, but their successors, have contributed to the same death roll every year. The causes are various: A heavy limb falls, broken by the wind; a tree "lodges," and, springing back from the stump, kills the axman; a load of logs "shoves" the team down some steep grade in the road, and the driver is thrown underneath or dashed against a roadside tree; a tier of logs starts suddenly; a jam on the log-drive breaks without warning; a man while fighting a forest fire finds his retreat cut off; another disappears in the current of the spring flood, and in the mills men fall upon the saws.

Accidents, painful but not fatal, also happened in the lumber woods. It is written in the records of the town of Middlebury, Wyoming County, that—

> In May, 1817, Artemas Shattuck went into the woods to chop. While cutting off a log that had been partially split open, his foot was caught in the crack, and he hung for a long time suspended by his foot and partly supported by one hand. Despairing of receiving aid, he finally unjointed his ankle with his pocketknife, made a crutch of a crooked stick, and started for the house.

Their privations had a pathetic side also, for we read in the history of the town of Verona, Oneida County, that "the first death in the settlement was that of a child who was buried in its cradle for want of a coffin."

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[a] History of the town of Queensbury. By A. W. Holden, M. D.

[b] Colonial Documents, Vol. IV.

[c] In the footnotes appended to the town histories in Hough's Gazetteer of New York there are twenty-one instances mentioned in which the first death among the settlers was caused by the falling of a tree.

RAFTING.

The local market of each mill was limited to the distance which the sawed lumber could be transported on wagons, over soft, newly built roads; no canals or railroads extended these limits. The greater outside market could be reached only by rafting the product and floating it down to the towns and cities, which were always located on some waterway. Hence, the mills were erected on the upper waters of creeks or rivers, which furnished at the same time water-power and an outlet to market. Every lumberman was a raftsman as well as a log jobber and mill owner.

Passing by the lumber operations during the first century of colonial life, of which there is now very little record, we come to that period in the history of the industry in the several counties which was marked by the running of the first rafts.

PIONEER RAFTSMEN.

Arthur Noble, proprietor of the Arthurboro and Nobleboro Patents, Herkimer County, built the first mill in that county in 1790. The first lot of lumber sawed in this mill was rafted down West Canada Creek, thence down the Mohawk to the Cohoes Falls, and then carted to the Hudson River at Albany, where it was loaded in sloops and shipped to Ireland.

In Broome County, in 1796, Edward Edwards built a sawmill on the Onondaga stream, at a place which is now in the town of Lisle. He was the first man to run a raft down the Chenango River. For sixty years after the first settlements the staple product of this county was white-pine lumber, which was rafted down the Susquehanna, sometimes to Norfolk, Va. The young men had not seen the world until they had made this trip. It was a life of adventure. The river journey brought to their view whatever there was of civilization at that period, and running the dams was perilous work that furnished material for thrilling naratives on their return. Other business as well as the lumber industry was dependent on the success of the raftsmen, and notes were made payable "when the rafts get back."[a]

In Delaware County, Jesse Dickinson, who, about 1788, built a mill on Trout Creek, in the town of Tompkins, ran the first raft that went down the West Branch of the Delaware River, the lumber being floated all the way to Philadelphia.

In Chautauqua County the first lumber floated down the Allegheny River was sawed at the mill owned by Dr. Thomas R. Kennedy, on

[a] In the town of Franklin, Delaware County, a large willow tree formerly stood in the highway near the house of Judge Wattles. It grew from a cane used by Judge Wattles in walking home from Philadelphia after "going down the river" upon a raft in the spring.

the Connewango Creek, in the town of Poland, near Jamestown. This mill was erected in 1805, and by rafting the boards in the Connewango, a tributary of the upper Allegheny, the product was taken to Pittsburg, the nearest market.

In Cattaraugus County the first lumber was rafted down the Allegheny River in 1807. The rafts were owned by Bibbins Follett, Jedediah Strong, and Dr. Bradley. The first sawmill in this county was built in 1801 at South Valley by the Quaker colony, and the lumber for the first raft may have been put in the river there, although in 1807 there were mills at Olean and Portville.

Every navigable river in the southern part of the State has been utilized at one time or another by lumbermen. Board rafts, bound for tide water or "tide," could be seen on the Chemung and Tioga rivers as late as in the sixties, and on the upper Allegheny they were a prominent feature of the lumber business until the construction of the railroad along the river shore from Pittsburg to its headwaters in Cattaraugus County, N. Y. The last of them went down the river about 1890.

RAFTING ON THE UPPER HUDSON.

The Hudson River was never used by raftsmen below Albany; for a raft could make no progress unless both wind and tide were favorable. The lumber was therefore carried in sailing vessels from Albany to New York or to the old country.

Mrs. Grant[a] in describing rafting on the upper Hudson, in 1768, says:

> It so happened that the river had been higher than usual that spring, and, in consequence, exhibited a succession of very amusing scenes. The settlers, whose increase toward Stillwater had been for three years past incredibly great, set up sawmills on every stream, for the purpose of turning to account the fine timber which they cleared in great quantities off the new lands. The planks they drew in sledges to the side of the great river; and when the season arrived that swelled the stream to its greatest height, a whole neighborhood assembled and made their joint stock into a large raft, which was floated down the river with a man or two on it, who, with long poles, were always ready to steer it clear of those islands or shallows which might impede its course. There is something serenely majestic in the easy progress of those large bodies on the full stream of this copious river. Sometimes one sees a whole family transported on this simple conveyance; the mother calmly spinning, the children sporting about her, and the father fishing at one end and watching its safety at the same time. These rafts were taken down to Albany, and put on board vessels there for conveyance to New York; sometimes, however, it happened that, as they proceeded very slowly, dry weather came on by the time they reached the Flats, and it became impossible to carry them further; in that case they were deposited in great triangular piles opposite our door. (See Pl. IV.)

The greater portion of the pine on the slopes along Lake Champlain was sent to market in rafts, through the lake and down its outlet—the Sorel River—to Canada, whence it was exported to England.

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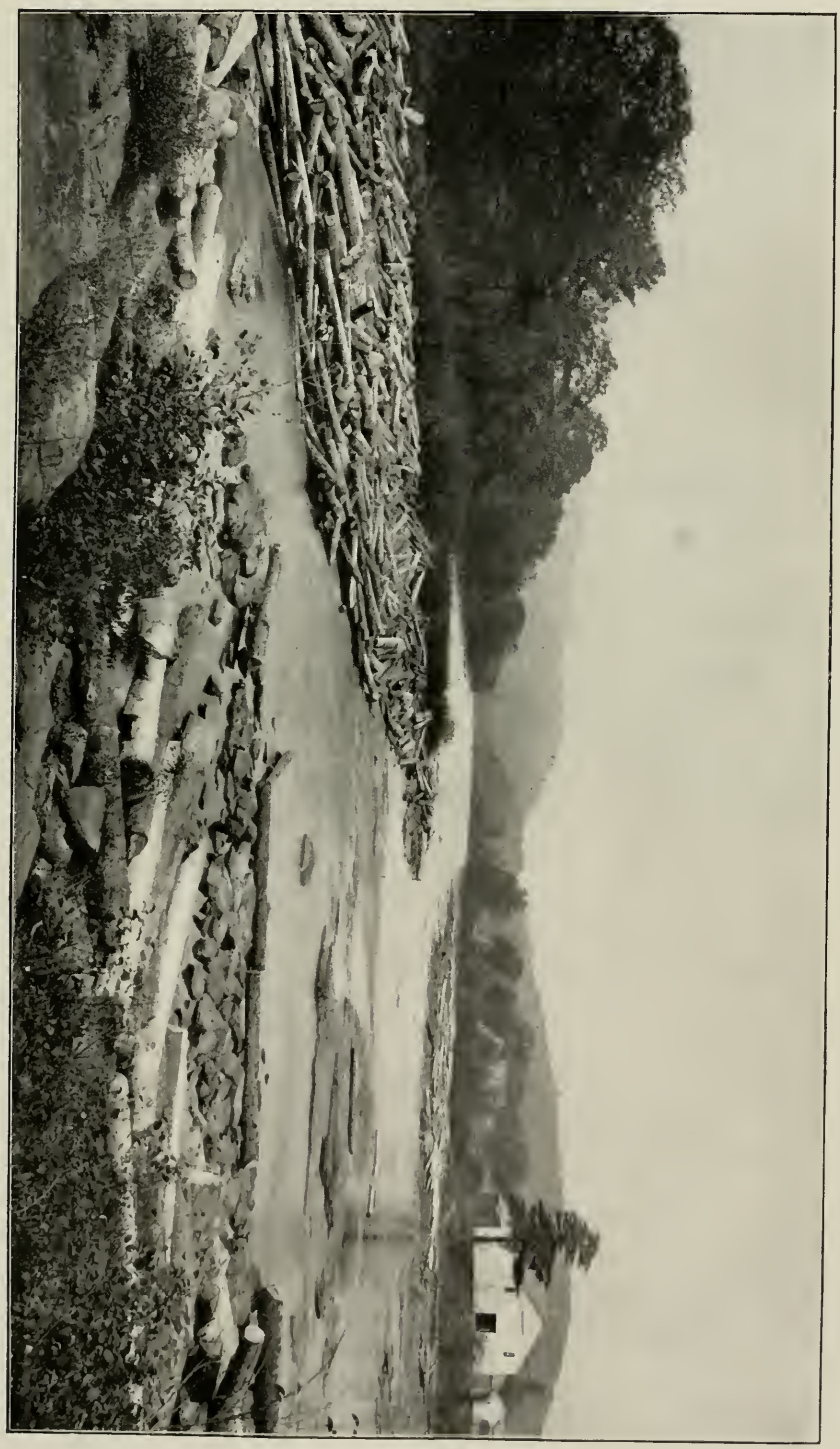
[a] Memoirs of an American Lady. By Mrs. Anne Grant. Albany: Joel Munsell, 1876



LOGS LEFT IN THE HUDSON RIVER AT LOW WATER.

In 1808, owing to international disputes, Congress laid an embargo on all trade with Canada. This restriction bore heavily on the lumbermen of Clinton County, who were dependent on the Canadian market. That year a large timber raft, said to have been a quarter of a mile long, lay at Isle la Motte waiting for a favorable wind to carry it over the line. The United States revenue officer, supported by a company of militia, was watching it, under orders to prevent any export of that kind. The bold raftsmen, undaunted by the display of military, pushed out into the stream, the soldiers following along the shore. After a brisk exchange of musketry and rifle shots, in which no one was injured, the lumbermen crossed the line and proceeded on their way without further hindrance.

CONSTRUCTION OF RAFTS.

No history of the lumber business in this State would be complete without some description of the construction of a raft. In 1865, and for several years subsequent, the writer was engaged in rafting on the upper Allegheny, both boards and square timber, putting in his rafts at Olean, Weston's, and Portville, in Cattaraugus County, N. Y., and running them to Oil City, Pittsburg, and Cincinnati. The details of the business, its varied scenes and incidents, are easily recalled to mind.

Board rafts, pine or hemlock, were from 24 to 30 courses deep, a "course" consisting of inch "stuff," or its equivalent in plank or joist. The number of courses varied according to the height of the "fresh" and the judgment of the pilot, on whose ability to handle the raft amid bars and shoals the owner was dependent for a successful and profitable trip. In that part of the State all logs were cut 16 feet long, except a small number of twelves, which were cut when necessary to save timber. Hence the platforms of a board raft were 16 feet square. They were built up in successive layers, the boards in each course being laid at right angles to those just below, thus binding them together securely.

At the corners of each platform, and at intervals along the four sides, round wooden stakes, about 2 inches in diameter, extended from the under side of the raft to the top, passing through augur holes in some of the boards. These "grub stakes," as they were called, were made of sapling trees peeled and cut away at the roots until only a knob remained at the lower end, which was larger than the augur hole in the boards above it through which the stake was passed. The binding boards in the top course were wedged solidly at the augur holes, so that the stakes could not pull out. Five platforms thus constructed were connected closely, forming a "five-platform piece." The larger rafts were made up by coupling three of these five-platform pieces side by side and fastening three more behind them. A raft of this size would then be 48 feet wide and 160 feet long; and if

it had twenty-five courses it would contain over 180,000 feet of lumber, board measure.

The greater part of this floating mass was submerged, the top course being from 6 to 8 inches above water. Occasionally a "deck load" of shingles or dressed lumber was carried on top; but the latter was not taken unless the owner intended to peddle it out along the river at places where there were no planing mills. (Pl. V.)

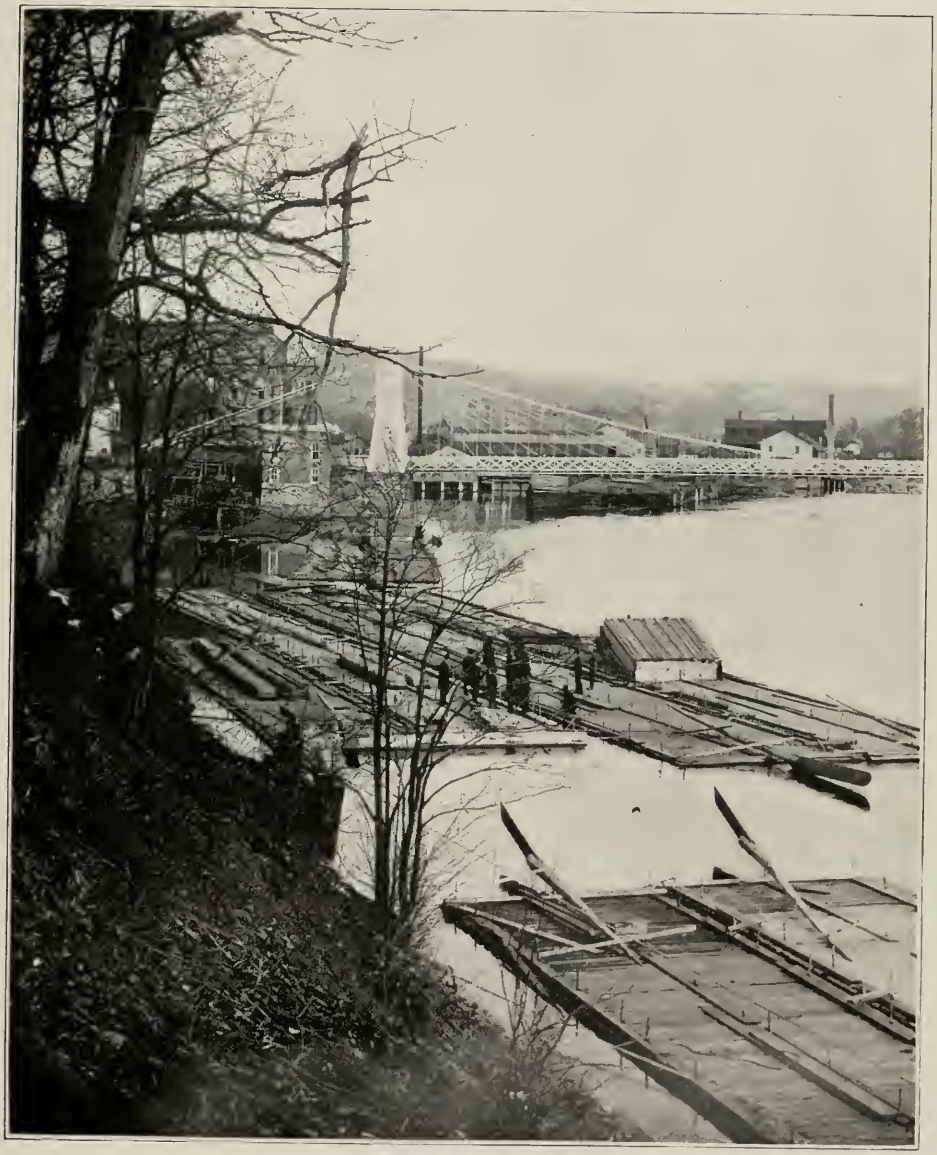
At the forward end of each five-platform piece was a large oar. On a raft such as just described there were three oars in front and three behind—not on the sides, but at the ends, projecting forward and backward. The oar blade was a 14-foot plank, 12 inches wide, thin on the lower edge; the oar, made from a small tree, was about 18 feet long and 8 or 10 inches in diameter at the large end, where it was attached to the blade. It was hewed tapering to the small end or handle at which the men stood. So large and clumsy were these rafting oars that two, and often three, men were necessary in handling them. When not in use the oars rested on the raft with their projecting blades just clear of the water. At the command of the pilot the blades were dipped by raising the handles high, and then the men pushing on the oars with hands lifted above their heads, tramped across the platform, bracing their feet against cleats nailed on the pathway for that purpose. The oars were used to move the raft sideways and keep it in the current; or, in turning sharp bends in the river, to swing it on its center by "crosspulling," in which the oars at the two ends were worked in contrary directions.

The work of the men was directed by a pilot, whose long experience had acquainted him with the rocks and bars and taught him how to take advantage of the swirling current or to avoid its treacherous force. As a large raft had six oars—three in front and three behind—a full crew required from 12 to 18 men, not including the pilot and the cook.

A shanty was built on one of the forward platforms, around the sides of which there were bunks in triple tiers. For bedding there was plenty of clean straw and coarse, warm blankets. A fireplace for the cooking was made just outside the cabin by placing four short boards on edge and filling the square with earth.

RAFTING ON THE ALLEGHENY.

On an ordinary flood the rafts would run from 40 to 50 miles each day. At nightfall the pilot would always swing in to the bank in some eddy, throw a cable ashore, and, with a turn or two around some large tree, "snub" the raft until its momentum was slowly overcome. Yielding to the crew, he generally tied up near some town or village where there were plenty of other rafts and company for the men in the



BOARD RAFTS ON THE UPPER ALLEGHENY, TIED UP FOR THE NIGHT IN AN EDDY.

tavern; there the question as to who was the best man and all other disputes were duly fought out. The Allegheny raftsmen were a stalwart type, many of them Indians from the Salamanca Reservation; and among them were not a few "bad" men, as they are termed in modern slang. After receiving their pay at Pittsburg, they generally walked home to Cattaraugus County, some of them doing easily 40 miles or more a day.

It was a pleasant, jolly, outdoor life, floating down the river through the forest-covered hills and mountains of the Alleghenies, gliding past the clearings and cabins of pioneer farmers, and running through villages or cities where the bridges were lined with people waiting to see the rafts go by.

Sometimes the raft carried one or more passengers—friends of the owner or pilot—people who were content with the plain fare and food provided.

But rafting had its trials and perplexities. Although the river dams were built with chutes or aprons to facilitate the passage of rafts, sometimes the long, floating mass would swing in the wind and current and "saddle bag" on the head of the bar below the dam. Then the boards had to be "rafted over," occasioning a delay which, on a fast falling freshet, often resulted in getting "stuck" again on some shoal farther down the river. There the raft would lie all summer, the lower courses filling with mud and the top course warping in the sun.

Bridge piers were always a source of danger, especially where there were three or four in close succession, as at Oil City and Pittsburg. Years ago the raftsmen delighted in telling the story of a Susquehanna pilot who said that there were 30 piers in the Columbia bridge, and he "run 'em all but one." The Susquehanna was a much more difficult river for rafting than the Allegheny—higher dams, more bridges, larger rocks, and more shoal water.

Many old-time lumbermen claimed that rafted lumber was better than any other, because the soaking of the boards so diluted the sap and resinous matter that when piled again in the yards it would season better and quicker. But any advantage thus gained was more than offset by the wet, muddy condition of the boards as they came from the river. Each course had to be scrubbed with a broom, and even then the front of each pile in the lumber yard was plastered with the mud scraped off as the boards were drawn up over the edge. Then, again, when the dried lumber was sent to the planing mill it was covered with a thin coating of dirt and grit that dulled the planer knives and filled the mill with a cloud of fine dust.

Hewed timber was also rafted to market. Fifty years ago most of the long timber was hewed instead of sawed, for the mills had no appliances then for sawing long sticks. Moreover, the hewed timber

was thought to be more valuable; it was stronger and would last longer than sawed timber wherever it was used. The sticks were of White Pine, ranging from 30 to 70 feet long and from 12 to 24 inches square. At one time considerable "square" timber, as it was called, was sent to the Albany and New York markets by canal, the rafts being made up into "lockbands" corresponding in size to the canal locks.

LOG-DRIVING.

Log-driving on the upper Hudson commenced about 1813. This idea of floating logs to mill was first used by the Fox Brothers, Norman and Alanson, in bringing their timber from the Brant Lake Tract to the mills at Glens Falls. These had previously been stocked by hauling the logs direct to the mill. Their example was quickly followed, and for seventy-five years the great sawmills at Glens Falls, Sandy Hill, and Fort Edward obtained their stock in this way, thereby centering the entire manufacturing business of the upper Hudson and its tributaries in that locality.

In time a sorting boom became necessary at some convenient place on the Hudson where the logs of the various lumber companies could be separated in accordance with the "log-marks" stamped on the ends of each log. This necessity, together with the frequent loss of stock by the breaking of poorly constructed booms in time of high water, caused the organization, in 1849, of the Hudson River Boom Association, and the construction of the "big boom" at Glens Falls. Here suitable arrangements were made for holding and sorting the logs belonging to the various mills located at or below that place.

From the books of this company it appears that in 1851 there were 132,500 "market" logs,[a] 19-inch standard, equivalent to 26,500,000 feet B. M., received at this boom. The next year 69,080,000 feet of logs passed through. These figures show approximately the extent of the lumber business on the upper Hudson at that time.

The business increased yearly until the maximum was reached in 1872, when 1,069,000 standards, or 213,800,000 feet, were handled at this point. At that time lumbermen were not cutting below 12 inches on the stump, or nothing less than "two-log" trees. Hence, the logs in the boom ran, on an average, about two to the standard, and the 1,069,000 standards delivered that year represented over 2,000,000 separate logs or "pieces."

After 1872 the business declined steadily until 1900, when the books of the boom company showed that 282,771 markets, or 56,554,200 feet had been received that year. These figures tell briefly the story of the rise and fall of the lumber business on the Hudson watershed.

[a] The market or standard log is 19 inches in diameter at the small end and 13 feet long.

STREAMS DECLARED NAVIGABLE.

At first the people living along the river objected strenuously to the use of the streams for floating logs to the mills. The first law declaring any river in this State a "public highway" was passed in 1806. This act provided that the Salmon River, in Franklin County, could be used for rafts and boats below Malone, and it enacted further that if any person shall "cut or fell any trees into the said river such person shall forfeit one dollar for each tree so felled and suffered to remain in the said river twenty-four hours." This same law, chapter 139, forbade any person from "rolling any log or logs into the Schroon River in Essex County, or doing anything to obstruct said river," under a penalty of $5 for each offense; but provided that nothing in the act should "prevent any person from rafting any lumber down said river they may think proper." The restrictions in this law as to obstructions will be read with interest by those who, in recent years, have noticed how many of our Adirondack rivers are filled at times for a long distance with a solid mass of floating logs through which no boat can pass.

But industrial interests are always recognized in time, and so, in 1854, the legislature declared the Salmon River "a public highway for the purpose of floating saw-logs and timber." In fact, a portion of the river was so used before the passage of this law.

In 1804 the legislature passed a law (chapter 103) to punish anyone who stole timber or lumber that was floating down the river or lying along the shore. This act refers to "any timber, hewed, sawed, or riven," terms which do not seem to include saw-logs, and which would indicate that only long timber, spars, and masts were floated down the stream at that time. Section 2 of this law provides a severe penalty for persons who shall "deface or alter any mark, or put a false mark on any such timber," from which it appears that "log-marks" were in use then, even if short logs were not driven down the stream. Nine years later a law was passed (chapter 34, Laws of 1813) requiring all log-marks to be recorded in the office of the town clerk of Queensbury, and the phraseology of this act shows that log-driving had commenced on the Hudson and "its branches to the northwest of Baker's Falls." In 1825 a similar act was passed for the protection of log-marks on the Au Sable River.

In 1810 the State legislature declared the Raquette River a public highway from its mouth to the bottom of the falls in the township of Louisville (St. Lawrence County) for rafts and boats. Chapter 264 of the Laws of 1850 declared the Raquette River a public highway for the purpose of floating logs and lumber from its mouth in the town of Massena to the foot of Raquette Lake, in the county of Hamilton.

The Black River was first declared a highway in 1821, the law pro-

viding for "rafting timber or lumber." The Grasse River was made a highway in 1824, and in 1854 an act was passed "to improve" this stream "for floating timber and saw-logs."

The years in which other rivers were delared public highways for floating logs were as follows:

Genesee River[a]	1818	St. Regis:	
Delaware River	1822	West Branch	1854
Saranac River	1846	East Branch	1860
Moose River	1851	Oswegatchie River	1854
Chateaugay River	1851	Sacandaga River	1854
Beaver River	1853	Great Chazy River	1857
West Canada Creek	1854	Deer River	1867

FLOODING DAMS.

After the merchantable timber along the main rivers had been cut lumbermen turned their attention to the more remote and inaccessible tracts on mountain slopes, where the streams were narrow, rocky, and rapid. Then commenced the erection of "splash" or "flooding" dams, which were used to drive the logs out of the small streams on the temporary, artificial floods caused by opening the gates, and also to reenforce the subsiding waters of the main stream.

These flooding dams seldom did any damage to standing timber, because the ponds were always drawn down in the early spring when the water was needed for log-driving, and the gates were left open until the next spring. There was no backflow during the period of vegetation, and the temporary flooding of the roots of the trees in the spring did not kill the timber. Trees are killed only where water is allowed to cover the ground for two or more successive summers. There is a general impression, however, to the contrary, and that the lumbermen with their flooding dams are responsible for the killing of live timber and the destruction of forest scenery. But the dead timber in the flowed lands of the Adirondacks is, in nearly every instance, the result of some dam or reservoir which was built in the interest of the State canals, local steamboat lines, or manufactories on the lower waters. The lumbermen had little or nothing to do with it.

In the southern and western portions of New York lumbermen rarely built these flooding dams. The country was not so mountainous nor the streams so rapid or violent as in the Adirondacks; the spring floods held up longer by reason of a less rapid flow, and log-driving was easier in every respect.

LOG-DRIVERS AND THEIR WORK.

The beginning of log-driving was coincident with the sudden increase in the development of the country at the commencement of the last

[a] In 1828 the Genesee River was declared a public highway from Rochester to the Pennsylvania line.

FIG. 1.—LOGS AND ICE—THE FIRST DRIVE—WEST CANADA CREEK.

FIG. 2.—LOG DRIVING ON THE AUSABLE RIVER.

century. Former primitive methods of hauling logs from the forest to the mill were no longer adequate to supply the increasing demand. The haul had become too long to be profitable, and there were no canals or railroads in those days. Hence it became necessary for the manufacturers either to move their sawmills upstream or to flood their logs down to the mills.

In a few years log-drivers were at work on every large river in the State. Logs which were cut and skidded in the fall were hauled during the winter to the shore of some stream, where they were piled in huge tiers on the "banking grounds," as they were called on the Susquehanna, or "landings" or "rolling-banks," in northern New York. With the first spring freshet, or often while the ice was still running, the blocking was knocked loose and the great piles of logs allowed to roll down into the turbid stream. When possible the logs were unloaded from the sleighs directly on the ice of some lake or stream, in order that they might go out with the ice on the first spring flood. (Pl. VI, fig. 1.)

In the lake region of the Adirondacks, river-drivers had the additional task of moving their logs through the lakes, where there was no current to assist their progress, but too often a contrary wind, that drove their logs back or scattered them. In passing through these lakes lumbermen generally rafted the logs or inclosed them in strongly connected booms, and then "warped" their way through the open water by using an anchor, a long heavy cable, and an upright windlass placed on the forward end of a strongly constructed raft. This work was often done at night, or whenever the lake was still and free from the strong winds so prevalent in early spring. Old river-drivers, in telling of the early log-drives, still describe how through the long hours and darkness they leaned wearily against the capstan bars as they tramped round and round the platform while "kedging" their way through the lakes.

The work of the river-drivers was perilous. Scarcely a season passed without someone being drowned or killed on some stream. Men were crushed under swift-rolling logs at the banking grounds, chilled to death in the icy waters, or killed in breaking the great jam which formed at every obstruction in the river. The most dangerous work was usually done by volunteers, and if all the deeds of heroism and self-sacrifice performed by river-drivers while attempting to save the life of some comrade in danger were recorded they would be found to equal anything in the histories of fire, flood, or battlefield.

The drivers were necessarily men of stalwart build and superb physique. With surprising agility they would leap from log to log while they were running down the rapid, swirling current; and, standing upright on a small log, with nothing to aid them but a pike-pole or lever, they would guide their treacherous craft as skillfully as an Indian his canoe. (Pl. VI, fig. 2.)

But the old-time river-driver is passing, and now, when the city hunter or fisherman makes his headquarters in some old, abandoned log-camp, he looks thoughtfully at the floor, thickly pitted with the marks made by the spikes in the river-drivers' shoes, and thinks of the days of the big "log-drives," while he listens to the guide who tells the story of how some "good man" met his death bravely in the white, foaming rapids on the head of the jam.

In later years, on the larger streams, the owners of the various mills usually arranged for a "union drive," the expense being shared by the log owners in proportion to the number of standards they had in the drive, this amount being determined by a tally kept at the sorting boom, or taken from the books of the log-scalers.

LOG-MARKS.

Each lumberman on the river had his own peculiar log-mark, which was stamped with a marking hammer on the ends of his logs while piled in the woods on the skidways, or before they were put into the stream. There were so many different firms operating on the upper Hudson that the ingenuity of the lumbermen was greatly taxed to devise new and distinctive marks for their floating property.

Some of the principal marks used from 1851 to 1890 on the upper Hudson and its tributaries, the Sacandaga, Schroon, and Boreas rivers, were as follows:

A. Wing & Co	⊕	Bradley & Underwood	DU
A. N. Cheney	☼	Kenyon Lumber Co	⧋
Tefft & Russell	○	Orson Richards	⊶
Morgan Lumber Co	♡	Van Dusen & Crandall	☆
James Morgan & Co	⊡	Freeman & Van Dusen	⊓
Finch, Pruyn & Co	𝓘	Cheney & Armes	⊠
Morgan & McEchron	OK	Lemon Thomson	Ƭ
W. H. Bloomingdale	X	Thomson, Douglas & Dix	Ð
D. W. Sherman	S	Union Bag and Paper Co	✚
A. Sherman	B	International Paper Co	⋊
George H. Freeman	□		

On the Tioga River the firm of Fox, Weston & Bronson used the following marks to distingnish the logs coming from their various timber tracts: ⧈◎△♡⋇.

Other marks used on the Tioga were as follows:

Ballard & Co	⊕	Cameron & Co	㉘

On the Oswegatchie River the logs of the principal firms were stamped as follows:

Starbuck & McCarty	8	Weston, Dean & Aldrich	♡

On the Indian River (Lewis County) Roberts & Brooks used this mark: ✢.

On the Raquette River the log marks recorded in the town clerk's office at Potsdam since 1851 included, among others, the following:

Ransom Jenkins

A. M. Adsit & Coc

Henry Hewett

Hewett & Townsend

Parmenter & Hitchings

George L. Stanton

Morgan, Rosekrans & Adsit

S. Chamberlain & Co

Hitchings & Hall

N. Pratt & Son

Ralph Pomeroy

Archibald Robertson

Ralph & Co

George W. Sisson

Sherman Lumber Co

Augustus Sherman

Burnham, Loveless & Co

M. S. Ballard

W. A. Griswold

Foster & Boswell

Harmon & Rice

Norwood Manufacturing Co

Watkins, Turner & Co

Export Lumber Co

Export Lumber Co

In addition to the foregoing there were a large number of log-marks on the Raquette in which letters or numerals were used.

The law requiring that the log-marks on the Raquette River should be recorded was passed in 1851. It allowed the town clerk 25 cents for recording each mark. Many of these marks had been in use on the Raquette River prior to 1851. Since then 102 different marks have been recorded, the last entry having been made December 4, 1900, by the Raquette River Paper Company.

On the Saranac River there were:

Maine Company

Christopher F. Norton

H. & O. A. Tefft

J. H. & E. C. Baker

Everitt C. Baker

Loren Ellis

Thomas & Hammond

Patrick Hanlon

D. H. & W. Parsons

As the different lumber firms went out of business from time to time and had no further use for their marks, the right to use them was usually bought by other lumbermen. To reprint all the different marks used on the many logging streams would occupy too much space. Those shown here will give some idea of what constituted a "log-mark." The characters were made in different sizes, but were usually from 1 to 3 inches in length and width. In some instances numerals instead of characters were used. In selecting a design for a log-mark care was taken to choose one which would easily be recognized as the log passed through the "gap" at the sorting boom; and the men who did the marking with the hammer were supposed to hit the log in several places on each end, so that whatever side might be up as it floated through the opening some one of the marks would

show plainly above the water. The river-drivers and men at the sorting boom necessarily became very familiar with the various log marks and had their own terms for them, suggested by some resemblance. Thus there was the crow's foot, double O, wine cup, triangle, hawk eye, box, deer's foot, anchor, etc. These marks were also of use in the mill yard or piling ground, as showing the job or firm to which the lumber belonged, a part or all of the stamp showing here and there on the ends of a board or plank.

With the introduction of railroads, logging cars, steam log-loaders, and jack-works for loading logs from the lake or stream onto cars, the lumbermen are no longer entirely dependent on river-driving for getting their stock to the mill. The railroad has the advantage of being available any month of the year, and the mills are not compelled to shut down in the dry season for lack of stock. There is no loss on account of having a drive "hung up" for many months, the logs deteriorating in the meantime. With the railroad the stock can be brought to the mill just as it is required.

LOG-RAILROADS.

The first railroad for hauling logs was built in 1852 by Fox, Weston & Bronson, in the town of Lindley, Steuben County, N. Y. It was constructed of wooden rails and was equipped with platform cars and a locomotive which bore on its cab the name "Bull of the Woods." This railroad was not used as a substitute for log-driving, but for hauling logs to the bank of the Tioga River, whence they were driven to the large gang-mills at Painted Post.

Our Adirondack lumbermen were quick to perceive the advantage of using railroads for transporting timber in localities where it was not possible to drive the logs and timber to the desired point for manufacture, and there are now several timber tracts in northern New York where all the logs are taken out by rail. However, it is an unquestioned fact that water furnishes the cheapest power for moving timber, as each time the logs are handled separately, in loading and unloading, adds to their cost, and the cost of transportation by rail almost invariably exceeds that of log-driving.

The use of the railroad makes it possible to get out hardwood timber, which otherwise could not be utilized because the logs are too heavy to be floated down the stream and would sink. The hardwoods—birch, maple, Beech, ash, and cherry—constitute, on an average, over 65 per cent of our northern forest. In the Catskills they form a still larger proportion. As this class of timber becomes accessible under the improved methods of logging the value of such timber lands is greatly enhanced, and this in turn will have a direct influence on the forest policy of the State. Hitherto the State has been purchasing forest lands at a low price. The lumbermen, after removing the small proportion of conifers, were willing to sell at a low figure,

because the remaining hardwoods could not be marketed and the taxes were burdensome. But now that the hardwoods as well as the others will probably be cut there is imperative necessity for more prompt and liberal action by the State legislature if the forests are to be preserved. Hitherto lumbering has meant a culling or thinning process, the removal of the evergreens only; it soon may mean denudation.

LENGTH OF LOGS.

The lumbermen of southern and western New York usually cut most of their logs into lengths of 16 feet to supply the market demand for 16-foot boards. They also cut some 12-foot and 14-foot logs in order to save timber. But boards of the shorter lengths were somewhat unsalable. In the Adirondack forests nearly all logs were cut 13 feet long. The reason for adopting this odd length is not known now. For nearly a hundred years the lumbermen of northern New York have cut 13-foot logs, sawed 13-foot boards, and sold 13-foot lumber in the Albany and New York markets, although logs everywhere else in the United States are cut into lengths of 16 feet or some other even number. Fifty years ago the 10-inch boards, 13 feet long, from the Glens Falls mills were known in these markets as "tally boards," and were sold by count instead of measure.

LOG-RULES.

Throughout the State, with the exception of the Adirondack country, lumbermen usually bought or sold logs by one of two rules—Doyle's or Scribner's. Prior to 1850 Edward Doyle and J. M. Scribner each published an original tabulation of figures, called a log-rule, showing the number of feet, board measure, which a log of any size would yield when sawed into inch lumber. For half a century or more the relative merits of these two rules have been a source of frequent discussion, there being a material difference in the figures given by the two authorities.

It may seem strange that there should be any difference over a mathematical problem of this kind. Certainly if the saws were of the same thickness and the sawyers equally skillful there could be no variation in the results. But logs are not cylindrical; they are tapering, sometimes crooked, often rotten in spots, and apt to be defective in various ways. Hence in formulating a log-rule for general use allowance must be made for slabs, saw-kerf, waste, and various defects that may be found in almost any large lot of logs. It was on this matter of allowance that Doyle and Scribner differed.

The Doyle rule is based on a fixed, arbitrary formula, which is fairly correct as to medium-sized logs, but is inaccurate, necessarily so, as to others. Starting with the 16-foot lengths, he arrives at the number of feet, board measure, in a log of that length and of any diameter by deducting 4 inches from the diameter and then taking the square of the difference. For instance, in finding the contents of a log 16 feet

long, 20 inches in diameter, he uses this formula: $(20''-4'')^2=256$ feet. Having determined the contents of the 16-foot logs, all other lengths are computed proportionately. Hence a log 12 feet long and 20 inches in diameter would contain 192 feet, or twelve-sixteenths of 256.

Scribner arrived at his table of contents by platting circular diagrams showing the number of square-edged boards in a log properly sawed. From these diagrams the amount of lumber was computed for each diameter, after which a fixed percentage was deducted for the imperfections common to an ordinary lot of logs.

Doyle's figures for the contents of small logs are much below those given by Scribner, while in large logs he allows more than Scribner. Both rules agree substantially on logs of 24 inches in diameter, the lines crossing at this point and diverging in opposite directions. For instance:

Diameter.	Length.	Doyle.	Scribner.
Inches.	*Feet.*	*Feet B. M.*	*Feet B. M.*
10	13	29	41
24	13	325	328
36	13	832	750
10	16	36	54
24	16	400	404
36	16	1,024	923

As a majority of the trees and all top logs are less than 24 inches in diameter, the sawmill owners, being the purchasers, naturally favor Doyle's rule. When logs were bought or contracted for with jobbers at a fixed price per thousand feet, the stock cost less money by using the Doyle rule. In letting log contracts to jobbers, or in purchasing logs from outside parties, the sawmill companies have always insisted on buying, contracting, and measuring logs by the Doyle rule, as it discriminates in their favor. As a result of this discrimination the old Scribner rule has gradually been abandoned and is rarely used at present.

On a lot of straight, sound logs from 10 to 20 inches in diameter Doyle's rule would be too severe, and the contents as shown by the saw-bill would overrun the log measurement. But with a lot of large hemlock logs (which, when sawed, are liable to run largely into second quality and cull lumber, because of the shaky timber and other defects) the Doyle rule would be more advisable if the purchaser expects his saw-bill to hold out, and to have a million feet of merchantable lumber for each million feet of logs bought. A scaler who thoroughly understands his business can, however, make the proper deductions in measuring the logs.

In the Adirondack region logs are usually bought and sold by the standard, a log of certain size being adopted as the unit, which is called the standard. The standard in general use is a log 13 feet long and 19 inches in diameter at the small end. All logs are measured and compared with this standard as a unit. The method of comparison for logs of the same length (13 feet) is to divide the square of the diameter of the log at its small end by the square of the diameter of the standard: that is, by 361. The result, whether decimal or whole number, expresses the size of the log in terms of the standard as a unit. In buying and selling logs, five standards are considered equivalent to 1,000 feet, board measure.

The standard log, 13 feet long and 19 inches in diameter at the small end, contains, according to the Doyle rule, 183 feet, board measure; according to the old Scribner rule, 195 feet. But it has repeatedly been proven by tests that a sound, straight, standard log, carefully sawed with a band-saw, will yield 200 feet, board measure, of straight-edged boards; and this is the assumption of the Adirondack lumbermen, who, in handling logs, speak of five standards as being equivalent to 1,000 feet.

In the Saranac region lumbermen formerly used a log 22 inches in diameter at the small end as a standard unit of calculation.

When speaking of the 19-inch standard, lumbermen often make use of the term "market" instead of standard, and speak of 20,000 standards as 20,000 markets, meaning 20,000 marketable logs; although, if the timber is small, it might take 60,000 separate pieces to actually scale 20,000 standards, or markets. The Adirondack lumbermen always estimate five 19-inch standards, or markets, as being equal to 1,000 feet of logs, board measure; hence a log-job or drive of 50,000 standards may be regarded as equivalent to 10,000,000 feet, board measure. These figures will be more easily understood by an outside lumberman. The idea of buying and selling logs using some certain size as the fixed standard originated with Norman Fox, a pioneer lumberman of Warren County.

The methods and rules for the measurement of logs have never been made the subject of any legislation in New York State. Laws have been passed, however, providing for the appointment of a certain number of inspectors and defining the number that may be appointed in each of the various districts into which the State has been divided for this purpose. In 1805 an act was passed for the inspection of lumber, rafts, timber, and spars, which allowed the inspectors to charge 37½ cents per M, B. M., and 14 cents per 40 cubic feet. The inspectors were required by this law to mark all lumber or timber which they had inspected with a "marking iron," showing the number of feet in each piece.

MODERN SAWMILLS.

The first sawmills in each locality throughout the State or colony were of a primitive character, containing one upright saw for which the power was furnished by an overshot water-wheel. In time an additional saw was inserted in the gate, and so on until the modern gang was evolved. (Pl. VIII, fig. 1.)

The first gang-mill was built on the Hudson River at Fort Edward; just when, the records do not show. It is asserted that the next one was erected in 1848 by Hinckley & Ballou, on West Canada Creek, in the town of Russia, Herkimer County, but prior to this year there were gangs running in the mills at Glens Falls, Sandy Hill, and Painted Post.

In 1848 Henry S. Shedd and Marshall Shedd, jr., erected a gang-mill in Lewis County at the lower falls of the Moose River, about 1 mile from its junction with the Black River. The gang in this mill contained 32 saws.

The first gang-mill on the Raquette River was built at Norwood, in 1851, by Morgan, Rosekrans & Adsit.

For many years after their introduction sawmills were operated by water-power exclusively. Their owners, having secured the best mill-sites on our rivers, did not need to run their mills by steam. Water-power was cheaper, and many of the largest gang-mills in New York use it to-day.

The large mills have not changed materially in the last forty years. In 1860 there were several in New York that ran five or six gates; say three gangs, a slabbing gang, and two English mills.[a]

Some used a Yankee gang instead of a slabber, and in the large mills, where two or more stock gangs were in use, one of them would contain about 36 saws, set for inch boards, while another would be hung with a smaller number, set for plank. Such a mill—six gates—would cut about 15,000,000 feet per year, running night and day, with an occasional shut-down for low water.

Steam mills as a class used a large circular saw (Pl. VII, fig. 2), although of late years there are mills in New York, as elsewhere, which run both circulars and gangs, to which band-saws have recently been added. (Pl. VII, fig. 1.) It is difficult to find any records showing when the first steam sawmill was built in New York State. A sawmill driven by steam power was built in 1830, in the town of Newark Valley, Tioga County, by Chester Patterson and Jonathan Day, which employed about 30 men. The engine had a walking beam, such as is used on steamboats.

In 1833 George Kirby erected a steam sawmill in the town of Nichols, Tioga County.

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[a] The English mill is an ordinary square gate or frame containing one or two upright saws, with a 16-foot carriage that gigs back.

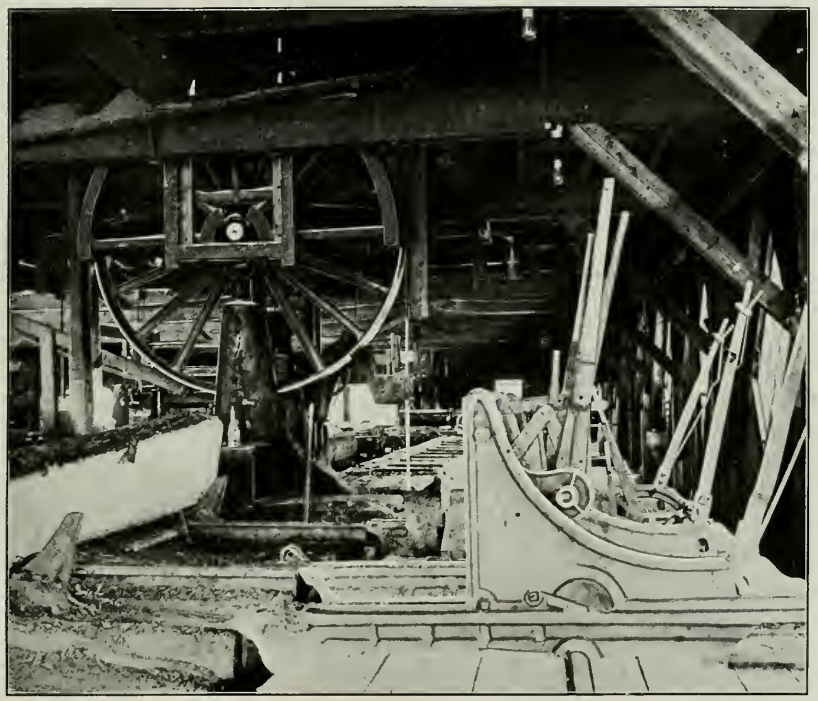


FIG. 1.—MODERN BAND SAW, TUPPER LAKE, N. Y.

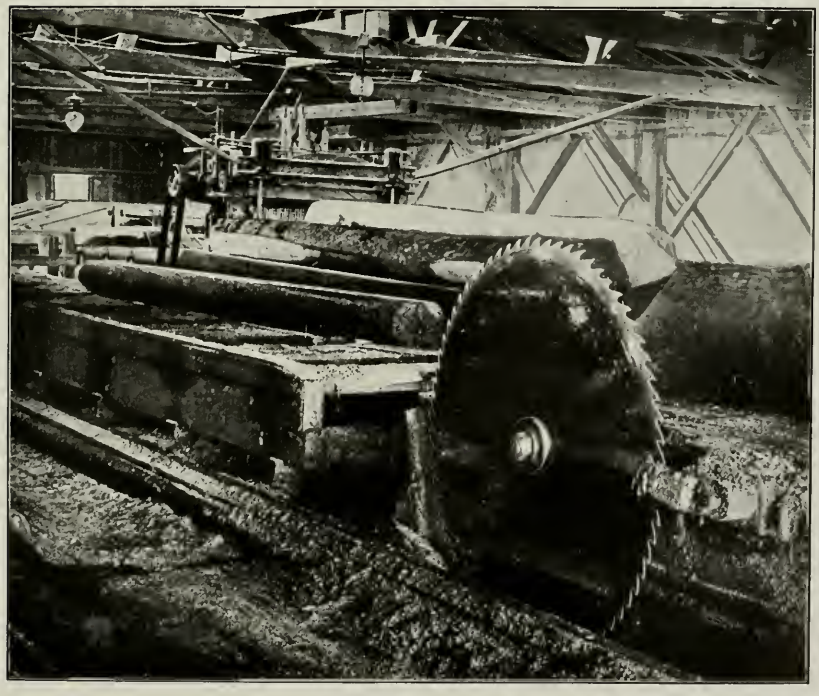


FIG. 2.—CIRCULAR SAW, TUPPER LAKE, N. Y.

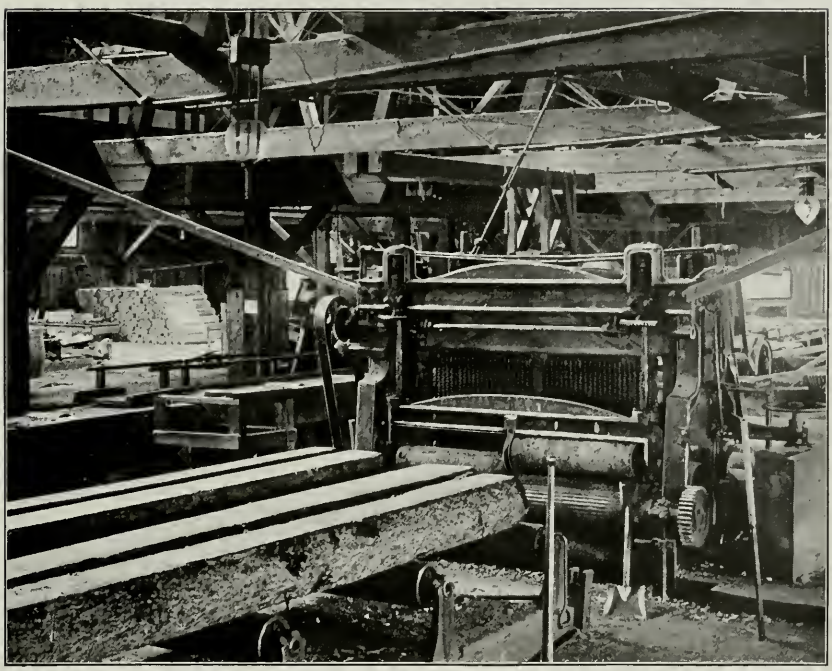


FIG. 1.—MODERN GANG SAW, TUPPER LAKE, N. Y.

The largest mill in the State, operating two gang saws, two bands, and two circulars.

FIG. 2.—JACK LADDER, WITH ENDLESS CHAIN.

In 1842 Dexter and Daniel Davis built one in the town of Caton, Steuben County. In 1844 a steam sawmill was erected in the town of Hammond, St. Lawrence County, by James E. Lyon. The first steam mill in Erie County was built at Tonawanda in 1847 by Col. L. S. Payne. In 1849 one was started by Kitts & Broadway in the town of Denmark, Lewis County.

TANNERIES.

Although the lumberman has little in common with the tanner, the demands of the latter had a material influence on that part of the lumber industry which belonged to the hemlock trade. To-day hemlock lumber finds a ready market, and at a price equal to that paid for spruce not many years ago. But a large portion of the Hemlock in this State was cut to supply the demand for bark only, the logs being left in the woods to decay and waste. This was particularly the case in the Catskill counties, where this species was more abundant than elsewhere in the State. Only the most accessible of the timber was hauled to the mills.

Bark-peeling in the Catskills ceased prior to 1870, and the great tanneries at Phœnicia, Woodland, Shandaken, Big Indian, and Prattsville had to abandon their business for lack of bark. The tannery at Prattsville, owned by Zadoc Pratt, was one of the largest in the State. Here 60,000 sides of sole leather were tanned and 6,000 cords of bark consumed annually for twenty-five years. Over 6,000,000 feet of hemlock was cut each year to furnish bark for this tannery alone, the greater part of the logs being left to rot after they were peeled.

The principal men in the tannery business in the Catskill region were Col. H. D. Snyder, Phœnicia; James Simpson, Phœnicia; Pratt & Sampson, Shandaken, and Zadoc Pratt, Prattsville. In 1865, according to the State census, there were 820 tanneries in New York; to-day there are not a dozen all told.

METHODS OF LUMBERING.

The present system of logging and lumbering has been evolved from the knowledge and experience gained by lumbermen in the early years of the industry. Many improvements have been made in tools and mechanical appliances; men are now better housed, fed, and paid: but the general principles, on which the business is conducted to-day, remain the same as in the days of the pioneers. Hence a description of the manner in which the work is conducted at the present time will give some idea of the methods employed a century ago.[a]

[a] A good description of life in the lumber camps as it existed many years ago may be found in the interesting volume, Forest Life and Forest Trees, by John S. Springer. 1856. New York: Harper & Brothers.

The experienced lumberman usually prefers to run his own camps, hiring a foreman to look after the work during his temporary absence; but a large portion of the timbering to-day is done by jobbers under contract. For example, a lumberman, landowner, or sawmill man, as the case may be, decides to lumber some certain tract. He lets a contract to cut the logs of a particular species on the tract, and deliver them to some point on a railroad, or on the banks of some stream, or upon some lake, whence they can be floated to the mill. This is called letting a log-job, and the man who contracts to do the work is called a jobber. In some places the contract is let by the thousand feet; in the Adirondacks it is usually let by the standard. The agreement is usually written in duplicate and signed by both parties.

The jobber commences operations by the erection of his logging camps, which are located on the tract in the most advantageous positions for removing the timber which is to be cut. The "bodies" of the camp are usually made of long logs, or sticks of timber rolled up and "notched" at the corners to hold them firmly in place. The cracks between the logs are firmly chinked with moss to keep out the cold. The roof is usually constructed with small pole rafters, covered with boards, these being covered with heavy tar paper. If the camp is to be used for several seasons, they sometimes shingle it with a cheap grade of shingles. A "tote" road is cut through the woods to the camp-site, over which the necessary boards, supplies, etc., are hauled. Bunks, tables, and partitions are constructed of rough boards. In early times no floors were laid, the earth being leveled off for that purpose. At the present time nearly all camps have floors made of boards or logs flattened. On the larger jobs the camps are built to accommodate from 80 to 100 men.

There is generally one large building, with an attic fitted up with tiers of bunks for a sleeping room, the ground floor containing the cook room and dining room combined, fitted up with long board tables on which the meals are served. (Pl. IX.) One end of this room is partitioned off for a "men's room," where the crew sit evenings, smoking, reading, singing, grinding their axes, telling stories, etc., before climbing the ladder to their night's rest in the bunk room. (Pl. X.) In many Adirondack camps at present they have a man cook, with an assistant known as the "cookee." But for many years women have been employed in camps as cooks, hence the name "men's room," for the crew are not allowed in the cook room except at meal time. Another log building, one story only, serves as a barn for the horses, and as a storehouse for the hay and oats. A blacksmith is an indispensable man in a logging camp, so a log building of suitable size is put up for his use, in which are a forge and all the tools for shoeing horses, mending chains, and repairing sleds. In the larger camps where a big job is being carried on, an additional building known

THE DINING ROOM, ADIRONDACK LOG CAMP.

THE MEN'S ROOM, ADIRONDACK LOG CAMP.

as the office is erected for the convenience of the foreman, the log-scalers, and the clerk, and as a store for the sale of such necessary articles as shoes, stockings, mittens, tobacco, etc. (See frontispiece.)

The "tote" road having been put in a fairly passable condition, the jobber hauls in his stock of provisions, tools, and feed for his teams; and he is soon followed by straggling groups of hardy looking men, some of whom, having spent their previous earnings in some metropolis of the wilderness, have no alternative other than another long sojourn in the lumber camps.

If the contract of the jobber includes hemlock and bark peeling, work begins in the early summer; for the bark will peel only from May 20 to August 20, or thereabouts. In this work each man is assigned his particular task. The best axmen are detailed for the felling of the large hemlocks. Others girdle with their axes the fallen tree trunks at intervals of 4 feet, and these are followed by men with "spuds"—iron tools with which they peel or pry loose the bark. The first "ring," the one at the base of the tree, is taken off before the tree is felled; otherwise the cutting at the stump would spoil this piece of bark. Another gang works as "swampers," in piling and ranking the bark ready for hauling.

With the approach of autumn the sap ceases to flow; the bark consequently sticks to the tree, and the work of peeling is ended for the year. The lumberman now turns his attention to cutting the spruce, pine, and balsam logs, and the forest echoes with the crash of falling trees. In early years all logs were chopped, but at present, for economic reasons, it is considered far better to saw them. There are men who show wonderful expertness in cutting a stump so the tree will fall exactly where it is wanted, some of them being able to stick up a stake as a mark, and to drive it into the ground with the falling tree. Some such skill is necessary in order to prevent the tree from "lodging" in another as it falls, to avoid piling it on down timber, and to avoid breaking young and valuable trees which may be standing near.

While the sawers are busy felling and cutting up the trees into logs, others are employed in lopping off the limbs from the logs, and preparing the skidding trail for the teams that haul the logs to the skidways. (Pl. XI, fig. 1.) The men cutting off the limbs are called "guttermen;" those driving the teams "skidders." The logs are rolled into huge tiers on the skidways, ready to be loaded upon sleighs when the snow comes. (Pl. XII, Pl. XIII, and Pl. XIV, fig. 1.) The skids were formerly cut from small spruce and were left lying in the woods to decay. At present, owing to improved methods and the increased value of the timber, hardwood skids are used if practicable. Whenever necessary to use softwood skids, after the logs have been removed they are cut up into the proper lengths, scaled, and hauled to the landings.

While on the skidways the logs are measured, or "scaled," as it is termed, the "scaler" taking the diameter of each log inside the bark at the top end and tallying it down in his book, after which a man with a marking hammer stamps the logs on both ends with the owner's mark. (Pl. XI, fig. 2.) The scaler generally has an assistant, for logs in large piles must be measured at both ends in order to determine which is the top, the body of the log being out of sight. Crooked or rotten logs are cut or "docked" in measurement enough to offset the defects.

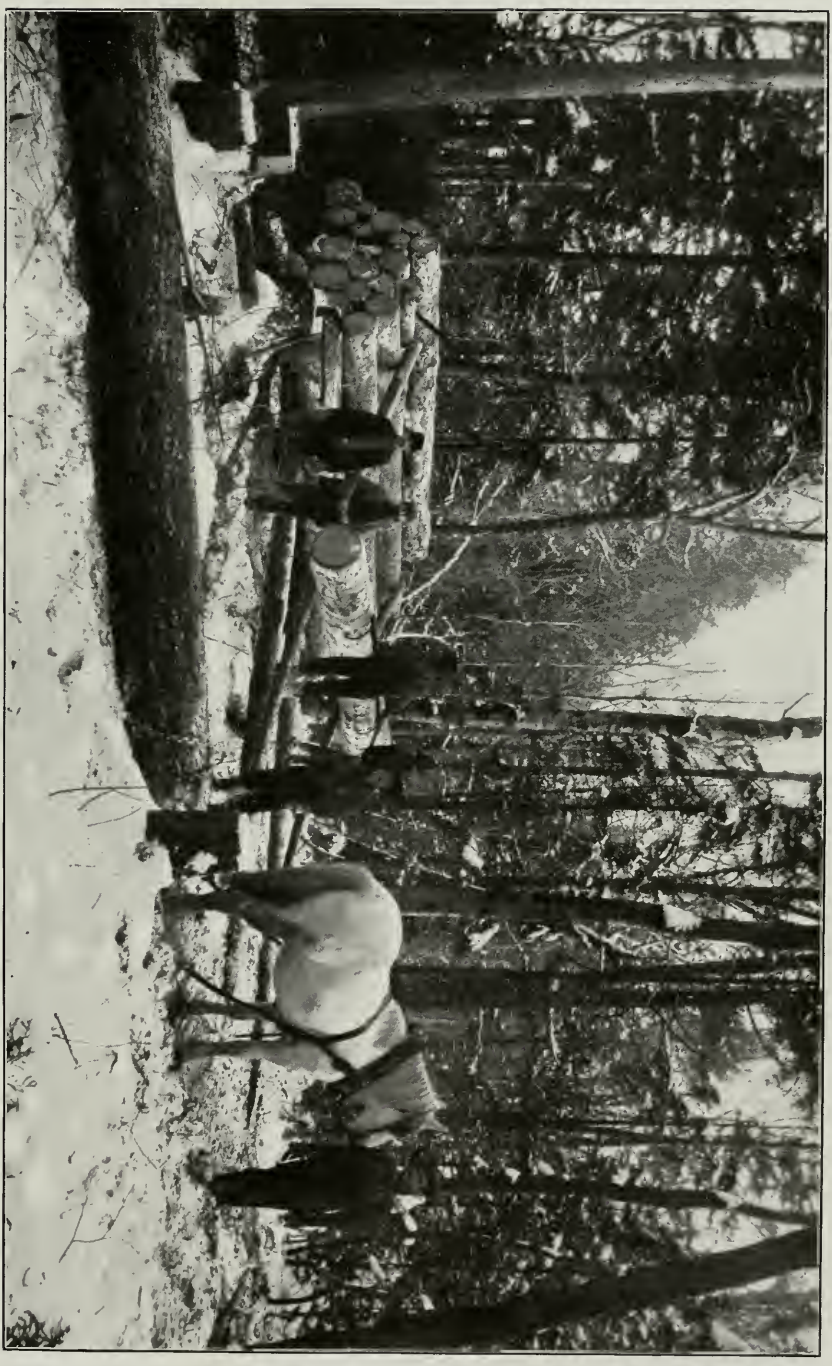
While the cutting and skidding is going on the jobber usually employs a portion of his crew building roads from the skidways to the main road, which in turn leads to the lake or river bank where the logs are to be unloaded. A diagram of the roads on a big lumber job would resemble a tree with subdividing branches, although a somewhat crooked one, owing to the curves and windings of the ravines or depressions down which the roads must go. This laying out of roads is an important part of the work, for upon the skill and judgment exercised much of the profit in the job depends. All necessary roads must be built, but unnecessary ones must be avoided. The jobber must exercise no little engineering skill in selecting a line that will reach all his skidways and at the same time preserve a practicable grade. It should be downhill all the way from the starting point, so that large loads can be hauled, and yet not so steep as to shove a team over the bank. Skill and experience are called for in the construction of sidehill or dugway roads, in bridge building, and in corduroying swamps.

The camps having been built, the bark peeled and ranked, and the skidways piled high with logs (Pl. XIII), upon the first deep snow the hauling commences. The roads are sprinkled from a large water tank, drawn on a sleigh, until a good ice bottom is formed, while on the steep grades sand and gravel are thickly spread to retard the speed of the loaded sleighs. Soon the landing or banking ground becomes a scene of activity. Teams drive up in quick succession to be unloaded, binding chains are unfastened by the unloaders, and the huge loads roll off the sleighs with a bumping, thumping noise as the logs rebound from the frozen earth.

The teamsters vie with each other in the size of their loads; and with the wide "bunks" now in use, iced roads, and heavy teams, a pyramid of logs is rolled up on the sleigh at the skidways until the driver, astride on the top log, is perched 10 feet or more above the ground. (Pl. XIV, fig. 2.) Some of the "champion" loads contain from 5,000 to 6,000 feet, although smaller ones are the general rule. A teamster is expected to make a specified number of trips each day, according to the length of the haul, which varies in most jobs from 1 to 4 miles, sometimes more. He must needs go to sleep early, because he must be up long before daylight, feed his team, get his

FIG. 1.—CUTTING SPRUCE LOGS, HAMILTON COUNTY.

FIG. 2.—MEASURING AND MARKING LOGS ON THE SKIDS.



SKIDDING LOGS IN THE ADIRONDACK FORESTS IN WINTER.

A SKIDWAY IN THE NORTH WOODS.

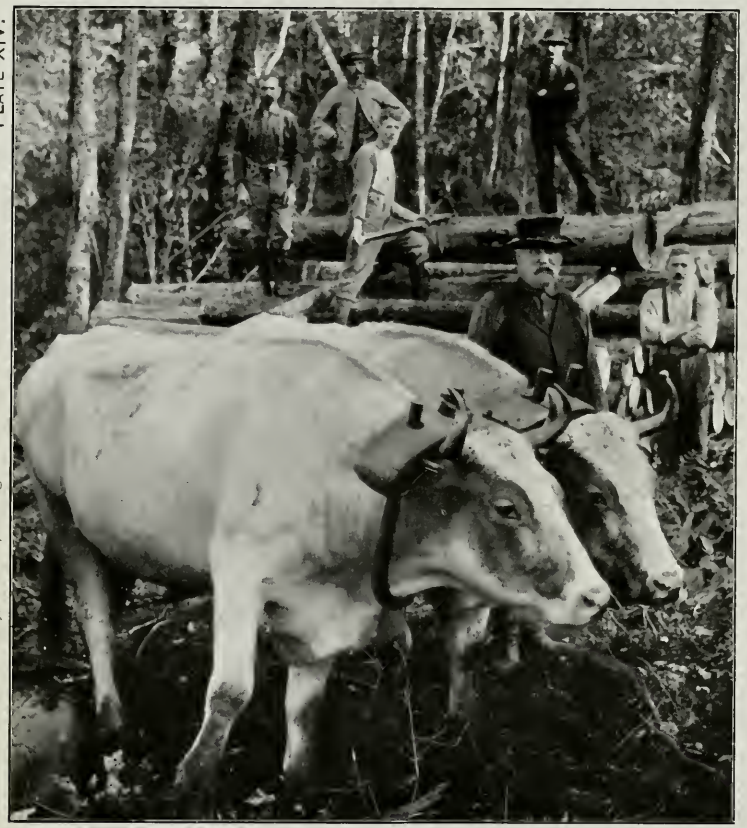


FIG. 1.—SKIDDING LOGS IN SUMMER.

FIG. 2.—A BIG LOAD ON THE WAY TO THE ROLLING BANK.

breakfast, and be off on the road while the stars are still shining clear and cold in the winter sky.

The average wages paid in the lumber camps of northern New York run about $28 per month, including board, with a distinction in favor of first-class men, to whom higher wages are paid. The jobbers are quick to recognize a good hand, and a man is paid what he can earn.

With the delivery of the stipulated number of logs at the river bank the jobber has finished his contract and "goes to town" to settle up with his employer. The men have been paid off and have taken their way to their homes or to some village, where too many of them soon part with their hard-earned wages. Old grudges are fought out, and not infrequently some luckless hero of the camp spends his vacation in the county jail. But as a class they are honest, brave, and industrious, reflecting credit on the great industry with which their life and labor are so closely identified.

When the spring thaw, with its warm south winds and rains, begins to loosen the ice in the upland streams and lakes, the boss river-driver collects his crew of stalwart, daring men, and again they start for the woods, where the thousands on thousands of logs are piled ready for the spring flood. Before the ice has fairly ceased running the logs are rolled into the water and the drive is on its way. Some of the men are stationed along the shores to prevent the logs from lodging or floating into bays or setbacks; some stand at the heads of the bars or islands, where with pike-poles they shove off the logs that might stop there and form a jam; others follow at the tail or rear of the drive and clear up the shore of such pieces as may have drifted out of the current and been left behind. Then there is the cook, most indispensable of all, who follows in the rear along the bank, pitching his tent from time to time in convenient places where the hungry crew can get their meals. (Pl. XV.) When the freshet is subsiding and the water falling rapidly so that the logs stick on every bar and along the shore, a splash dam is opened, and with the oncoming flood the work is resumed with all its interesting, active scenes.

At times, in some crooked, rocky stream, a jam is formed and thousands of logs are wedged fast in the channel, held back by some one log firmly braced against an impediment. Then occurs a thrilling scene as the foreman calls for volunteers to break the jam. There is always a prompt response. Two or more daring fellows, impelled by pride in their work, take their lives in their hands, and, with an ax and handspikes, make their way over the treacherous logs to the head of the jam. Behind them are thousands of logs, filling the angry stream from bank to bank, piled thickly to the bottom, in all shapes, tossing, tumbling, and leaping in the air as the dammed-up torrent forces them about in wild confusion. Beneath the men is the swaying, rocking, unstable mass, somewhere in the midst of which is the log

which forms the key to the position. The balance of the crew of drivers gather on the bank below, where they watch with intense anxiety the men who have volunteered to break the jam. They note every motion of the volunteers as they coolly and undauntedly proceed with their work. The critical moment is close at hand. There is a little more prying with the handspikes, a few more blows with the ax, and then suddenly the huge, threatening mass begins to move. Above the sound of the foaming waters a warning shout goes up from the men standing on the bank, and then, leaping from log to log, as the jam "breaks," the brave fellows reach the shore in safety amid the applauding cheers of their comrades; or, it may be, as a cry of horror breaks from the crew, one loses his foothold and disappears beneath the terrible, grinding mass, crushed and torn to a mere semblance of humanity. His body is found later in the river below, and another chapter is added to the unwritten records of heroism to be related in the next year's camps by his former companions, who, in subdued tones, tell the story of the man who lost his life on such a stream last spring.

So amid scenes of toil and danger the work is done. The drive is safely inclosed in the big boom at the mills, and the job is completed. (Pl. XVI.)

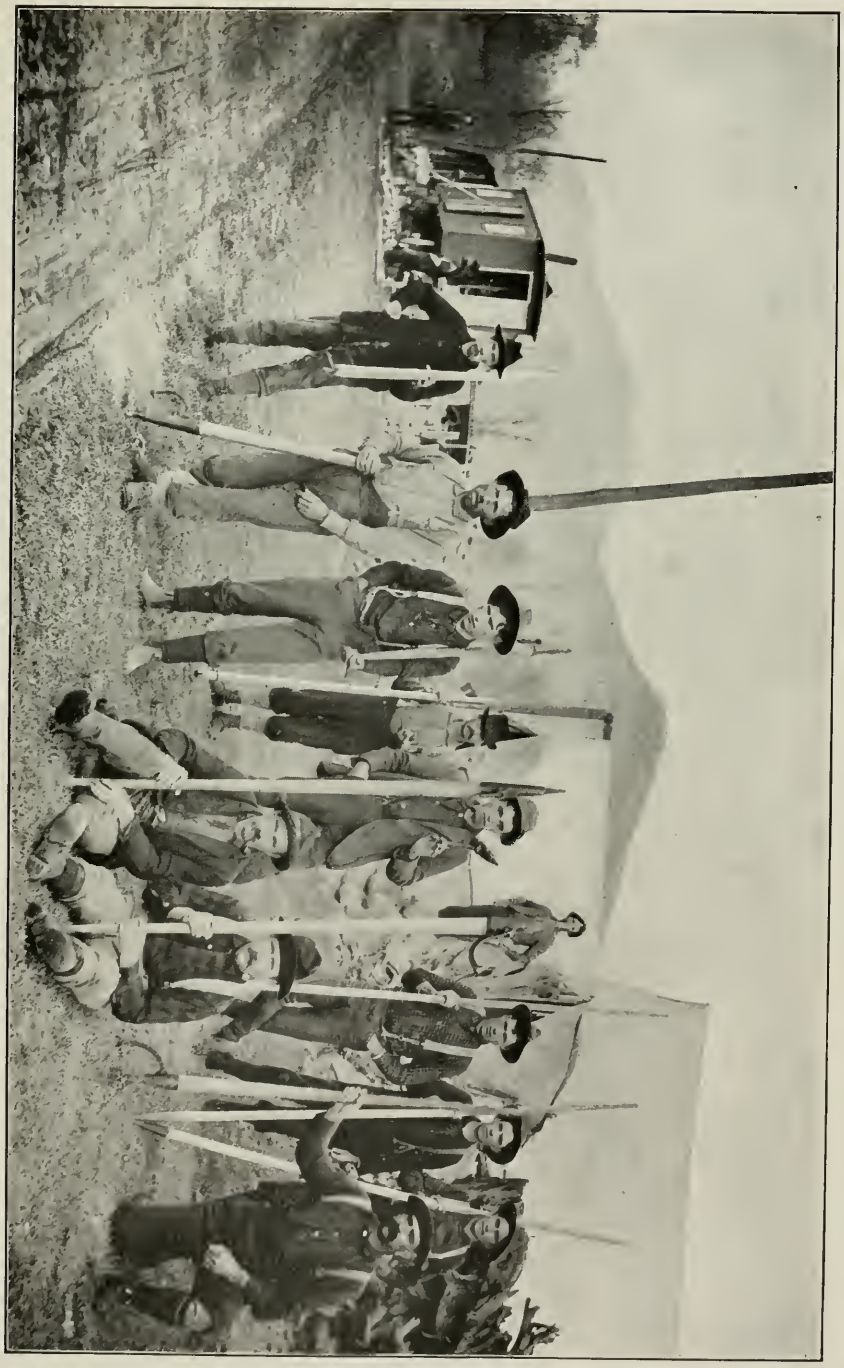
There is probably no industry which involves so many varied details as the business of lumbering; none which requires so close attention at every stage of the work; and none in which intelligence, strict economy, and, above all, thorough experience, are so necessary to profitable results. Failures in it have been so many that no one should undertake it who has not within him these specified requisities to success.

MODERN IMPROVEMENTS.

Some of the more important changes that have taken place in lumbering methods, mainly within the last century, are worth noting.

The chopper no longer uses a single-bitted ax. The tree is sawed, not chopped, into logs of the required length. In cutting down the tree a crosscut saw is used instead of an ax. The forester in charge of the job insists that all trees be cut as close to the ground as possible to save the timber lost in a high stump. On some jobs the logs are skidded by wire ropes and steam power. Iced roads, easy grades, wide "bunks," and attention to details enable teams to haul much larger loads of logs. In some places water-slides, miles in length, render log hauling unnecessary. Logs are placed on cars by steam loaders, lifted from lakes or streams by steam jack-works (Pl. VIII, fig. 2), and taken to the mills on railroads instead of by driving down the rivers. The introduction of the planing mill[a] built up a new and distinct branch

[a] The Woodworth planing machine was patented in 1828, and the patent was extended twice.



RIVER DRIVERS, SLEEPING TENTS, AND PORTABLE COOK SHANTY.

FIG. 1.—RAQUETTE POND AND PILING GROUND.

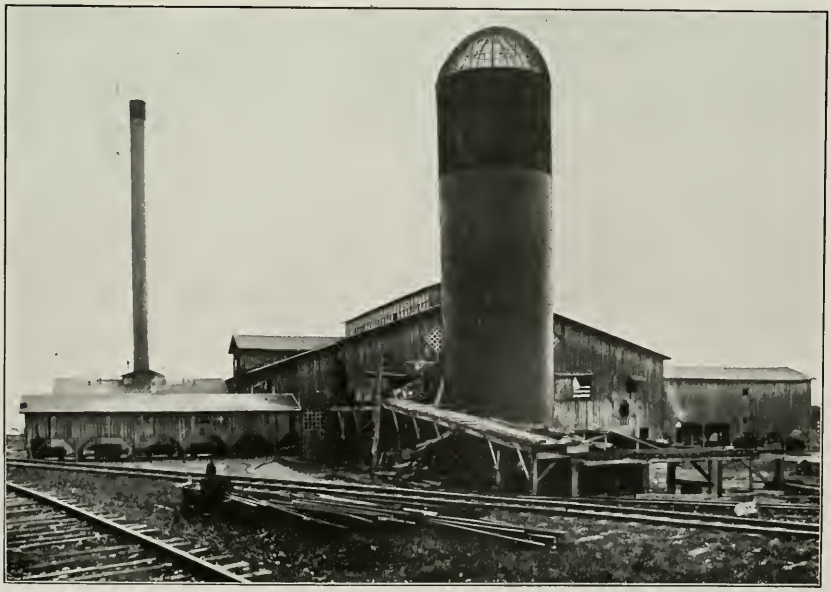


FIG. 2.—THE REFUSE BURNER FOR THE DISPOSAL OF SLABS, EDGING, AND SAWDUST.

of the lumber business. In modern sawmills we find the oscillating gang, circular saws with inserted teeth, mechanical appliances for handling logs, live rollers, and that most profitable of all improvements, the band-saw.

Until recent years the word "forest" was seldom heard except when used rhetorically. It belonged to poetry and literature. The lumbermen and the people used the word "woods" instead. People lived in the backwoods, went into the woods, came out of the woods, or were lost in the woods—never the forest. People spoke of the North Woods, the South Woods, the "Nine-mile" Woods, and the Shattygee (Chateaugay) Woods.

But now we hear the words forest and forestry. And in chronicling the improvements in the lumber industry of New York State mention must be made of the intelligent, conservative methods recently introduced in the management of public and private woodlands by professional foresters, whose working plans insure the preservation of the forests and the perpetuation of the timber supply.

"CAPTAINS OF INDUSTRY."

In recording the rise and progress of the lumber business, some passing tribute, at least, should be paid to the memory of the men who were prominently identified with this important factor in the development of the wealth and resources of the State. They were men of both physical and mental vigor, possessed of sturdy virtues that made them respected, not only in the communities where they lived, but wherever they were known. They had a keen sense of honor and fair dealing that made them known and described as men whose "word was as good as their bond"—a common, homely expression, but one carrying praise that was well deserved. The grass has been growing on their graves for many years, but their memory is still cherished, their influence for good is still felt, and the world is better for their having lived.

Among the men now dead and gone who were prominently connected with the lumber business on the upper Hudson, mention should be made of Abraham Wing,[a] James D. Weston, John J. Harris, Albert N. Cheney, Lewis L. Armes, Walter Geer, Orlin Mead, George Sanford, Orson Richards, Augustus Sherman, James Morgan, Charles H. Faxon, and Lemon Thomson.

On the Raquette River: Edward King, Ralph Pomeroy, Charles Pearson, George Richards, Matthias Vickery, James H. Carpenter,

[a] "Mr. Wing, born in 1791, had the foresight and judgment requisite for improving the golden chance by bringing to market the splendid pines with which the great Brant Lake tract abounded. This rich and extensive lumber region, previously operated by the Fox Brothers, Alanson and Norman, had come into the possession of parties in Troy, who intrusted its management to Mr. Wing." (History of Queensbury, by A. W. Holden, M. D. Glens Falls: 1849.)

Edward W. Hutchings, Lyman H. Wilcox, Harrison Plummer, A. M. Adsit, and E. H. Rosekrans.

On the Tioga River: Deacon Simeon Hammond, Abijah Weston, William C. Bronson, William B. Stevens, Benjamin Harrower, and Julius Tremaine.

On the Saranac River: Senator Christopher F. Norton, Almon Thomas, James Hammond, David H. Parsons, Wales Parsons, Hartwell Brothers, O. A. Tefft, and Loren Ellis.[a]

In western New York: John G. Mersereau, of Portville, and the Weston Brothers, of Olean.

WOODPULP.

Within twenty years the logging industry in northern New York has been materially affected by the demand for material necessary in the manufacture of woodpulp, an industry of comparatively recent development. Ground pulp, obtained by holding blocks of wood against a grindstone, was first made in this country in 1867, at Stockbridge, Mass. Chemical mills, in which the fiber is reduced by the action of acids under steam pressure, were introduced about the same time. Now there are 293 mills, mechanical and chemical, in the United States, of which 102 are located in New York. Wisconsin comes next with 37, and Maine has 30.

At first the New York mills used poplar only. This was deemed a desirable condition by our foresters, because this species does not appear to be available for any other purpose, while at the same time it is the kind of tree with which nature most quickly reforests burned areas in the Adirondacks. But poplar was soon discarded in favor of spruce, to which have been added within the last five years some of the other conifers, the process of manufacture having been improved so that a satisfactory fiber is now being obtained from Hemlock, pine, and Balsam.

The effect on timber cutting was soon evident. Where the lumbermen formerly took nothing less than two-log trees, leaving nearly all that were 12 inches or less in diameter on the stump, the woodpulp men cut all the trees of certain species, large and small. This close cutting of spruce and other kinds left no provision for future growth, and thinned the forest so severely in places that further damage was inflicted by wind and ice storms. The river-drives, which were formerly composed of fair-sized logs, were mixed thickly with smaller logs, and on some streams where pulpwood only was being driven, the drives were entirely made up of 4-foot lengths. The methods employed in cutting pulp timber differ somewhat from those used

[a] For interesting and valuable facts relating to the history of lumbering in the Saranac Valley, see paper read by Hon. Everitt C. Baker before the Plattsburg Institute January 14, 1901, and printed in the Plattsburg Sentinel January 18, 1901.

FIG. 1.—BEGINNING OF WATER SLIDE. THE ROLLING BANK.

FIG. 2.—THE SLIDE BUILT ALONG SLANTING ROCK.

FIG. 1.—ASLEEP AT HIS POST—WAITING FOR A JAM.

FIG. 2.—A DASH.

FIG. 1.—A PLUNGE. END OF WATER SLIDE, AUSABLE RIVER.

FIG. 2.—FOUR-FOOT PULPWOOD LOGS. AT REST AT LAST.

in getting out logs for sawmills. Where no forestry is practiced, the very small trees, as well as large ones, are cut. They are sometimes sawed into short lengths of 4 feet, thus making the work of handling the timber easier, although as the logs are too small to sustain a man's weight it makes the river-driving harder. It is usually considered more advantageous to cut the timber in lengths of 12, 14, and 16 feet. If it has to be driven and sorted from other timber this is undoubtedly the best method. Formerly only the small trees and the top logs were used for pulpwood, large timber being reserved for the sawmills and cut into usual lengths; but as the demand for woodpulp increased the stumpage became more valuable for that purpose, and on some tracts all the spruce timber, both large and small, was cut for pulpwood. The largest spruce in the Adirondacks, so far as known (41 inches in diameter on the stump), was cut for pulpwood. On some pulp jobs the bark is peeled from the trees in the woods in order to save freight, and as the bark has no commercial value it is left where the peeling or "rossing" is done. A mass of dry bark-strippings, covering the ground thickly in places, greatly increases the danger from fire. Much of the pulp timber in the Adirondacks is hauled directly to some railway station, and from there is shipped to the mills, as at the present market prices it will bear transportation a long distance. In some places the pulp logs are driven down some stream into a lake or pond near a railroad, where by means of steam jack-works they are loaded on cars. In other localities a long haul by teams is dispensed with by the construction of water-slides or wooden troughs several miles in length, through which a shallow stream of water carries the sticks to the railroad or to some river, whence they are driven to the pulp mills in the same manner as in a log drive.

In the vicinity of Benson mines, St. Lawrence County, there is a water-slide 3 miles long for conveying pulpwood to the railroad. This trough is 24 inches wide at the top and 10 at the bottom, with a depth of 20 inches. It is capable of moving 60 cords per hour. The company operating this slide had at one time a pile of pulpwood 1,000 feet long, 26 feet high, and 40 feet wide, all of which had been transported from the woods to the railroad by this novel method. They had also an additional slide in which sawed lumber was transported from the mill to the railroad. The J. & J. Rogers Pulp Company, of Ausable Forks, Essex County, N. Y., have on one of their jobs a water-slide 7 miles long, by which their pulp stock is carried to the Ausable River, where it is driven to their mills. (Pls. XVII, XVIII, XIX.)

In 1898 the total cut of logs in the Adirondack forests amounted to 544,234,207 feet, of which 229,581,918 feet was consumed in the pulp mills.

A peculiar effect of the woodpulp industry is the rise in value of

spruce stumpage. This has increased beyond the point warranted by the market value of the sawed lumber. Spruce stumpage is now worth so much for woodpulp that the sawmill men are unwilling to pay the price demanded for the standing timber, and unless there is some change in market conditions this species will not enter so largely hereafter into building operations, its place being taken to a great extent by Hemlock or cheap pine.

VOLUME OF BUSINESS.

The lumber industry of New York attained its maximum development at some time prior to 1865, when there were, according to the State census of that year, 3,963 sawmills. Perhaps three-fourths of this number were mills equipped with one saw only, none of which cut over 100,000 feet in a year.

From the Tenth United States Census, 1880, it appears that there were then 2,822 mills in New York, with an invested capital of $13,230,934, giving employment to 17,509 men, and paying out annually $2,162,972 in wages. The combined lumber product of these mills amounted in 1880 to 1,148,220,000 feet, board measure, not including lath, shingles, and staves.

Within the next twenty years there was a great decrease in the production, the timber supply having been exhausted in the Adirondack and Catskill forests. There are not 150 mills in the State to-day with an annual output of over 100,000 feet. The production is now confined almost wholly to the Adirondack region, the mills which are stocked from there having sawed in 1899 the following amounts:

Spruce	feet B. M.	148,203,491
Hemlock	do	46,545,772
Pine	do	33,132,807
Hardwood	do	24,296,554
Total	do	252,178,624
Shingles	number	33,619,000
Lath	do	49,329,090

To the amount of sawed lumber should be added 195,568,623 feet of logs that went to the pulp mills, making the total forest output of northern New York that year 447,747,247 feet.

There are several small sawmills in the Catskill counties, with a few others scattered throughout the western part of the State, their combined product not exceeding 60,000,000 feet. The advocates of forest preservation and the protection of our economic resources need no better argument than is contained in the figures showing the great decline in this industry within the last twenty years.

EDITOR'S NOTE.—The author, in his report as superintendent of forests for the State of New York (contained in the Seventh Annual Report of the New York Forest, Fish, and Game Commission, Jan-

uary 30, 1902), places the output of northern New York for 1900 at 533,339,072 feet, of which 230,649,292 feet was spruce for the pulp mills; the combined product of the Adirondack and Catskill forests for the same year at 651,135,308 feet; the number of employees in the sawmills of northern New York at 8,617, with annual wages aggregating $1,846,930; the number of employees in the pulp mills at 9,382, with annual wages aggregating $3,040,478.

The preliminary summary of the Twelfth Census concerning sawmills, planing mills (operated in connection with sawmills), and timber camps, places the total amount of timber from all sources sawed in New York State in 1900 at 878,448,000 feet, and the value at $12,364,362.

PROFITS OF THE INDUSTRY.

In many localities within the State there are lumbermen who have amassed large fortunes and attained prominence on account of their wealth. Their well-known success has created an impression that the lumber business is an exceptionally profitable one. This, however, is not the case. There is very little money in buying logs, sawing them, and marketing the product. The rich lumberman, in almost every instance, owned large tracts of timber land, and his wealth represents the appreciation in value of this kind of property; in his ordinary business—that of the logging camp and sawmill—he made a fair living profit, and nothing more. People seldom make much money in log jobbing or in sawing "custom logs." The lumbermen who owned no timber lands, and had to buy their logs or stumpage, were obliged to do business on a narrow margin of profit. Thorough experience, combined with the utmost economy in connection with every detail, was necessary to avoid a failure. Of this latter class some, through thrift and business tact, secured a comfortable competence before old age ended their activity; some barely held their own; while, as in all other kinds of business, the percentage of failures far exceeded that of success. But the men who owned the forest lands from which their mills were stocked could keep their business going on a low market that would ruin the operators who had to buy logs, saw the stock, and depend upon the market for a margin. The landowners could run their mills during a period of financial depression, and, although they were getting nothing for their stumpage, were always on hand and in the market when there came a rise in prices.

LUMBER MARKETS OF NEW YORK.

In addition to the ordinary lumber business connected with forest and sawmill, there were in the State of New York great lumber markets or distributing points where lumber was sold, not only the product of the State, but immense shipments from Canada and the

Northwest as well. The two principal markets were at Albany and Tonawanda.

Albany was the center of a great lumber trade sixty years ago, and at one time surpassed all other points in the amount handled and volume of business. In 1872 there were 43 wholesale firms, with yards grouped in the "lumber district," who handled, in the aggregate, 660,000,000 feet that year, their total sales amounting to over $15,000,000. Over 1,500 men were employed in the yards unloading and loading vessels, or in piling lumber, their total annual wages exceeding $600,000. But owing to increased facilities for making direct through shipments from the mills to the retailers, combined with unfavorable discriminations in freight rates, the business at Albany has declined so largely that the amount of lumber handled this year will not exceed 200,000,000 feet. The White Pine from this market is shipped chiefly to New England (including Boston, Newport, Fall River, and Nantucket), to Long Island, the Hudson River towns, New York City, the West Indies and South America, the Azores and Africa, and Australia. The shipments of spruce are confined mostly to Greater New York, Long Island, and Hartford.

Tonawanda, unlike Albany, is a market in which all the lumber handled comes from outside the State—from the great pineries of the Northwestern States and Ontario. Still, some mention of it seems pertinent on account of the volume of the business done there. Next to Chicago and New York City, it is the greatest lumber market in the United States or Canada. The entire stock received is reshipped by rail or canal to other places, wherein it differs from Chicago and Greater New York, the latter places consuming a large portion of their lumber receipts within their own limits.

The business at Tonawanda commenced in 1857, when its first cargo of lumber was shipped from Canada by Brunson & Co. In 1865 it had become an important point in the general lumber business of the country, and its trade increased steadily until 1890, when it attained its maximum volume. In the latter year the receipts from the Great Lakes at this port amounted to 718,650,900 feet, to which may be added 13,039,600 lath and 52,232,300 shingles. Their combined values indicate a business that year of over $16,000,000. The number of persons employed—yard men, planing-mill hands, stevedores, and office men—is estimated at over 3,000, their aggregate annual wages exceeding $1,500,000. But the shipments have declined materially within the last ten years, the receipts in 1900 being reported at 396,429,483 feet. This decrease is due to through shipments from the West of carload lots direct to the retail yards in the Eastern States, and to disadvantages in freight rates. Still, the lumber business at Tonawanda is immense, employing a great many men and distributing a large amount of money annually in wages; and, as a distributing point for New England and

the Middle States, it contributes materially to the commercial supremacy of New York.

Oswego was also an important distributing point, where a large amount of Canadian lumber was handled and reshipped by canal. In 1870 the receipts of lumber at this port amounted to 289,315,329 feet.

The city of New York, owing to its export trade and large local demand, is also the center of an immense lumber trade. In the year 1900 the total receipts of lumber from ocean, canal, river, and rail aggregated 1,246,014,604 feet.

The lumber industry in this State has been affected to some extent at different times by the tariff laws relating to Canadian imports. Until recently the amount of lumber imported from Canada equaled or exceeded the amount produced in the State; and the fact that New York is a border State, with numerous entry ports on the lakes, already in close proximity to the Canadian mills, and brought still nearer by easy rail and water transportation, rendered its markets peculiarly susceptible to foreign competition, and attracted thither the bulk of the importation. In 1854 Hon. William L. Marcy, then Secretary of State at Washington, made a reciprocity treaty with Canada, under which lumber was admitted into the United States free of duty for ten years. Since 1865 the duties on sawed lumber have varied, and in some years have been withdrawn altogether. The present tariff imposes a tax of $2 per 1,000 feet on sawed lumber, which is equivalent, on an average, to an ad valorem duty of about 13 per cent.[a] Under this impost the Canadian imports have fallen off one-half within the last two years.

Such, in brief, is the history of lumbering and the lumber industry in the State of New York brought down to the present time. It is interesting to note that improved methods of lumbering and a conservative system of forestry have been introduced in the woodlands of the State, which mark a distinct epoch in the history of the industry and promise to make the forests a still more important and beneficent factor in the economy of the Commonwealth. Already some of the largest private timber tracts in northern New York are being lumbered under a system that not only insures immediate profit, but makes ample provision for forest preservation and a perpetual timber supply. The cutting is restricted not only to certain species, but to a fixed diameter, which leaves a good number of the same species as the basis of another crop. Further provision for the future growth of mer-

[a] The present tariff, enacted in 1897, puts a duty of $2 per 1,000 feet on sawed pine, spruce, hemlock, balsam, maple, birch, beech, elm, ash, and walnut; and a duty of $1 per 1,000 feet on whitewood, sycamore, and basswood. Cedar, when sawed, is admitted at 15 per cent ad valorem. On planed lumber an additional charge is made of 50 cents per 1,000 feet for each side dressed; and 50 cents more per 1,000 feet for tongued and grooved boards or flooring.

chantable timber is made by leaving, at suitable intervals, healthy individuals to serve as seed trees in propagating a wind-sown crop of seedlings in the openings. Economical methods of felling trees have been introduced which protect the young growth and in addition yield more timber per tree. New industries have arisen that are dependent on forest products and utilize much of the material which heretofore has gone to waste.

The work is placed under the charge of skilled foresters, who mark each tree that is to be cut, and allow nothing cut that is not marked. The protective functions of the forest are carefully guarded, and no trees whatever are allowed to be cut on steep sidehills, or where a cutting might result in windfalls, soil erosion, or denudation.

The great primeval forests owned by the State have been carefully examined by competent foresters. Intelligent working plans have been made under which the matured timber may be removed from time to time and a permanent annual revenue secured to the State whenever the present constitutional restrictions are removed. And so, profiting by the lessons of the past and encouraged by the success of the present, the great lumber industry of the State enters upon another century of its existence with every promise that it will continue to add its full share to the honor and prosperity of the Commonwealth.

APPENDIX.

THE ROLL OF PIONEER LUMBERMEN.

It may fairly be assumed that in each locality throughout the State the commencement of the lumber industry was coincident with the erection of the first sawmill; all work before that was confined to individuals who labored to supply their personal needs only. But with the building of a mill there ensued a combination of labor to supply a general demand, which constituted to some extent what is known as lumbering operations.

In the statistics here appended will be found the year when the first settler located in each town mentioned, the list including the greater part of the State; also, the year in which the first sawmill was built in that town, together with the name of the pioneer who built it. Most of these towns of course had no existence then as towns, and the date given here means that the foundation of the first settlement or sawmill occurred at that time in a locality which to-day is within the town named.

The historical facts here given were compiled by the author from the various town and county records in the State Library at Albany. Much valuable information relating to the first settlement of each town was found in Hough's Gazetteer of the State of New York, and some interesting facts connected with colonial times were obtained from Dr. O'Callaghan's Documentary History of New York.

As this part of the work necessitated a careful examination of the early history of each one of the 977 towns in the State, it will be seen that the task required no small amount of time and patience. This information, however, will be of little interest to the general reader; and the question may arise whether the result is worth the cost. In answer it should be said that any history of the lumber industry must properly commence with the beginning of that industry, and that there was no other way to determine when it began except by ascertaining the date when the first sawmills were put in operation in the various localities.

It may be noticed that the list is incomplete as regards some of the towns in the Hudson and Mohawk valleys. An exhaustive examination was made of the town and colonial records relating to that region, but with only partial success, as but little mention is made in them of the erection of sawmills, or of the lumber industry. These valleys, however, contained the oldest settlements, and from their borders the wave of civilization spread outward through the State, its advance being marked everywhere by the advent of the lumberman and his mill. Next came the church and the schoolhouse.

The beginnings of the lumber industry in the State of New York.

County.	Town.	First settlement.	First sawmill.	Built by—
Albany	Albany	1630	1654	Jacob Janse Flodder.
	Berne	1750	1755	Jacob Weidman.
	Coeymans	1673	1651	Hans Jansen.
	Knox	1789	1800	Amos Crary.
	New Scotland	1700	1760	Uziah Conger.
	Watervliet	1700	1775	Shaker Colony.
	Westerlo	1763	1795	Lobdell & Baker.

The beginnings of the lumber industry in the State of New York—Continued.

County	Town.	First settlement.	First sawmill.	Built by—
Allegany	Alfred	1807	1821	E. S. Davis.
	Allen	1820	1820	Moses Treat.
	Alma	1833	1843	John W. Post.
	Almond	1796	1806	Phineas Stevens.
	Amity	1804	1806	Philip Church.
	Andover	1795	1819	Luther Strong.
	Angelica	1802	1803	Philip Church.
	Belfast	1803	1809	David Sanford.
	Birdsall	1816	1823	Hull & Peterson.
	Bolivar	1819	1822	Cowles Brothers.
	Burns[a]	1805	1813	David McCardy.
	Caneadea	1803	1816	John Hoyt.
	Centerville	1808	1813	Blanchard & Hotchkiss.
	Clarksville	1822	1832	Samuel King.
	Cuba	1814	1815	William Downer.
	Friendship	1806	1815	Ebenezer Steenrod.
	Genesee	1823	1820	Newman Crabtree.
	Granger	1816	1819	Isaac Van Nostrand.
	Grove	1818	.....	John S. Culver.
	Hume	1807	1807	Roger Mills.
	Independence	1798	1800	John Cryder.
	New Hudson	1820	1829	James Davidson.
	Rushford	1808	1815	Matthew P. Cady.
	Scio	1805	1822	Benjamin Palmer.
	Ward	1817	1818	Stephen Easton.
	Wellsville	1801	1803	Nathaniel Dyke.
	West Almond	1816	1833	Enoch Hawks.
	Willing	1825	1829	Elijah Robinson.
	Wirt	1812	1824	Alvin Richardson.
Broome	Barker	1791	1801	Simeon Rogers.
	Chenango	1784	1788	Henry French.
	Colesville	1785	1792	Robert Harper.
	Conklin	1788	1808	Robert Corbett.
	Fenton	1788	1797	Elisha Pease.
	Lisle	1791	1796	Edward Edwards.
	Sanford	1787	1791	Nathan Dean.
	Vestal	1785	1795	Bethias Du Bois.
	Windsor	1786	1797	Nathan Lane.
Cattaraugus	Allegany	1820	1826	Reuben Lamberton.
	Carrollton	1814	1826	Marcus Leonard.
	Cold Spring	1820	1820	Crook & Basson.
	Conewango	1816	1819	Sampson Crooker.
	Dayton	1810	1817	Silas Nash.
	East Otto	1812	1823	Moses T. Beach.
	Ellicottville	1815	1821	Orin Pitcher.
	Farmersville	1817	1824	James Worden.
	Franklinville	1806	1809	Henry Conrad.
	Freedom	1811	1821	Enoch Howlett.
	Great Valley	1812	1812	James Green.
	Hinsdale	1806	1815	Lewis Wood.
	Humphrey	1815	.....	Foster B. Salisbury.
	Ischua	1812	1814	A. M. Farwell.

[a] The first deaths among the settlers in this town were those of Jeremiah Gregory, who was killed by the fall of a tree, April 4, 1812, and his twin brother, killed in the same manner, on September 17, same year.

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
Cattaraugus	Leon	1819	1824	Ebenezer Collar.
	Little Valley	1807	1809	David Powers.
	Lyndon	1808	1843	Jason Sherman.
	Machias	1813	1822	Andrew McBuzzell.
	Mansfield	1817	1837	Clark Brothers.
	Napoli	1818	1829	James Wait.
	New Albion	1818	1836	Mathew Nealy.
	Olean	1804	1807	Shepard & Thrall.
	Otto	1816	1822	Isaac W. Sherman.
	Perrysburg	1815	.....	Isaac Balcom.
	Persia	1811	1814	Ahaz Allen.
	Portville	1805	1807	Green & Dodge.
	Randolph	1820	1823	Thomas Harvey.
	South Valley[a]	1798	1801	Quaker Colony.
	Yorkshire	1810	1814	Isaac Williams.
Cayuga	Brutus	1800	1808	Lewis Putnam.
	Conquest[b]	1800	1808	—— Twitchell.
	Sterling	1805	1817	John Cooper.
	Throop	1790	1798	Prentice Palmer.
Chautauqua	Arkwright	1807	1818	Benjamin Orton.
	Carroll	1807	1811	John Frew.
	Charlotte	1809	1810	Samuel Sinclair.
	Cherry Creek	1812	1824	William Kilbourn.
	Ellery	1806	1808	William Bemus.
	Ellicott	1806	1808	Edward Works.
	Gerry	1811	1819	Hines & Newton.
	Hanover	1797	1804	Abel Cleveland.
	Harmony	1805	1810	Reuben Slayton.
	Kiantone	1807	.....	Robert Russell.
	Mina	1816	1824	Alex Finley.
	Poland	1805	1805	Dr. Thos. R. Kennedy.
	Pomfret	1804	1807	Baker, Berry & Co.
	Villenova	1810	1815	John Kent.
	Westfield	1801	1804	John McMahan.
Chemung	Ashland	1788	1800	Isaac Baldwin.
	Baldwin	1813	1828	Elisha Hammond.
	Big Flats	1787	1795	William Miller.
	Catlin	1816	1827	James Wheeler.
	Chemung	1786	1790	Maj. Wm. Wynkoop.[c]
	Erin	1815	1824	McMillan Brothers.
	Horseheads	1787	1805	Nathan Teal.
	Southport	1788	1798	Col. Abraham Miller.
	Van Etten	1795	1800	Isaac Swartwood.
	Veteran	1775	1805	—— Teal.
Chenango	Afton	1786	.....	Cooper & Miner.
	Columbus	1791	1794	Job Vail.
	Green	1792	1795	Conrad Sharp.
	Lineklaen	1796	.....	Catlin & Shipman.
	Macdonough	1795	1798	Henry Ludlow.

[a] The mills did work for the white settlers on the usual terms, and furnished lumber for the Indians free.

[b] In 1804 James Perkins built the first framed house, sawing out all the lumber with a whipsaw. The building was still standing in 1859, a monument of persevering industry.

[c] Major Wynkoop built the first frame house in this town, the boards and timbers for which were sawed out with a whipsaw.

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
Chenango	New Berlin	1790	.....	Job Vail.
	Norwich	1788	.....	Elisha Smith.
	Otselic	1800	.....	James Rush.
	Smithville	1797	1805	Timothy Scoville.
Clinton	Altona	1800	1819	Benjamin Mooers.
	Ausable	1794	1806	Thaddeus Mason.
	Black Brook	1823	1825	Burt & Vanderwarker.
	Champlain	1789	1787	Lieut. Pliny Moore.
	Chazy	1783	1801	Atwood Brothers.
	Clinton	1818	1850	John McCoy.
	Ellenburg	1800	1824	John R. Murray.
	Mooers	1796	1804	George Perry.
	Peru	1785	1810	John Cochran.
	Plattsburg	1765	1769	Count de Freydenburgh.
	Saranac	1802	1806	Isaiah Ferris.
	Schuyler Falls	1794	1801	Ezra Turner.
Columbia	Canaan	1766	1774	Col. William B. Whiting.
	Kinderhook	1661	1665	Frank Pieters Clavers.
	Livingston	1708	1710	Robert Livingston.
Cortland	Marathon	1794	.....	John Hunt.
	Taylor	1794	1816	Rockwell Brothers.
	Virgil	1792	1801	Daniel Edward.
	Willet	1793	.....	Benjamin Wilson.
Delaware	Andes	1770	1811	John Vaughn.
	Bovina	1792	1802	Matthew Russell.
	Colchester	1774	1790	William Rose.
	Davenport	1786	1792	Daniel Prentice.
	Delhi	1784	1800	Oliver Peake.
	Franklin	1784	1806	Samuel Hutchinson.
	Hamden	1779	1799	Peake & Ward.
	Harpersfield	1776	.....	Col. John Harper.
	Kortright	1773	1780	Ezekiel Johnson.
	Masonville	1792	1799	Joseph Bushnell.
	Middletown	1763	1790	Benjamin Akerly.
	Roxbury	1789	1805	—— Ferris.
	Sidney	1772	1790	—— Carr.
	Stamford	1790	1795	Joseph Warn.
	Tompkins	1780	1786	Jesse Dickinson.[a]
	Walton	1785	.....	M. Goodrich.
Dutchess	Rhinebeck	1700	1740	Jacob Rutson.
Erie	Alden	1810	1814	John C. Rogers.
	Amherst	1800	1801	John Thompson.
	Aurora	1804	1806	Phineas Stephens.
	Brant	1818	1822	Samuel Butts.
	Cheektowaga	1808	1810	Samuel Le Suer.
	Clarence	1799	1804	Asa Ransom.
	Colden	1810	1811	Richard Buffum.
	Collins	1808	1809	Quaker Colony.
	Concord	1807	1812	Rufus Eaton.
	East Hamburg	1804	1803	David Eddy.
	Eden	1808	1811	Elisha Welch.
	Elma	1829	1832	—— Estabrook.

[a] This mill, soon after its erection, was carried away by the famous "punkin flood" that inundated the valleys of the Susquehanna and its tributaries in the fall of 1787. The cornfields were swept bare, and the yellow pumpkins that thickly dotted the surface of the swollen streams were so conspicuous that the descriptive name just mentioned survives among the household words in southern New York.

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
Erie	Evans	1804	1815	——— ———.
	Holland	1807	1815	Ephraim Woodruff.
	Marilla	1829	1828	Jesse Barton.
	Sardinia	1809	1812	Sumner Warren.
Essex	Chesterfield	1792	1802	Robert Hoyle.
	Crownpoint	1804	1810	Allen Penfield.
	Elizabethtown	1792	1814	Amos Rice.
	Essex	1783	1784	Daniel Ross.
	Jay[a]	1796	1798	William Mallory.
	Lewis	1798	1809	Asa Farnsworth.
	Minerva	1804	1807	William Hill.
	Moriah	1785	1810	Alexander Spencer.
	North Hudson	1802	1812	Elihu Phelps.
	Schroon (now Schroon Lake)	1797	1814	Joseph Richards.
	Ticonderoga[b]	1769	1772	Fox & Huntington.
	Willsboro	1765	1767	William Gilliland.
	Wilmington	1803	1812	Reuben Sanford.
Franklin	Bellmont (now Belmont Center)	1816	1825	Roswell A. Weed.
	Chateaugay	1796	1797	David Mallory.
	Constable	1800	1803	James Welch.
	Dickinson	1810	1830	Warren Ives.
	Duane	1823	1823	James Duane.
	Fort Covington	1794	1796	William Gray.
	Franklin	1827	1827	McLenatham & Wells.
	Malone	1802	1804	N. & J. Wood.
	Moira	1803	1803	Appleton Foote.
	Westville	1800	1801	Amos Welch.
Fulton	Broadalbin	1783	1810	Duncan McMartin.
	Garoga	1785	1790	Cornelius Van Allen.
	Ephratah	1743	1808	Henry Yanney.
	Johnstown	1760	1762	Sir Wm. Johnson.
	Mayfield	1761	1773	Do.
	Oppenheim	1791	1806	Henry Cline.
	Stratford	1799	1806	Martin Nichols.
Genesee	Alabama	1806	1824	Samuel Whitcomb.
	Alexander	1802	1804	Rea & Fellows.
	Batavia	1801	1801	Joseph Ellicott.
	Bergen	1805	1811	Jared Merrill.
	Byron	1807	1813	William Shepherd.
	Darien	1803	1809	Amos Humphrey.
	Elba	1801	1810	Horace Gibbs.
	Oakfield	1801	1811	Christopher Kenyon.
	Pembroke	1804	1808	Samuel Carr.
	Stafford	1801	1810	Amos Stow.
Greene	Ashland	1785	1820	Marshall Lewis.
	Cairo	1760	1808	Enoch Hyde.
	Catskill[c]	1650	1684	Dirk Tennisse Van Vechten.
	Coxsackie	1695	1750	Casparus Bronk.
	Durham	1770	1783	Jared Smith.

[a] "In the vicinity of Upper Jay the lumber business was killed as early as 1820 by the girdling of all the trees to facilitate the clearing of the land." (Hist. Essex Co., by H. P. Smith, 1885. Syracuse: D. Mason & Co.)

[b] The French troops, while engaged in the construction of Fort Carillon, built a sawmill at the outlet of Trout Brook, but it was destroyed soon after.

[c] A grist and saw mill combined. Robert Livingston, in a letter writte in 1712, says: "A little mill at Catskill grinds so coarse it can not be bolted."

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
Greene	Greenville	1750	1800	Nathaniel Holmes.
	Halcott (now Halcott Center)	1800	1820	Henry Hosford.
	Hunter	1800	1820	Roger Bronson.
	Jewett	1783	1795	Laban Andrews.
	Lexington	1777	1824	John Bray.
	New Baltimore	1785	1800	Charles Titus.
	Prattsville	1712	1823	—— Smedburg.
	Windham	1817	1817	Jared Clark.
Hamilton	Arietta	1827	.....	—— ——
	Benson	.....	.....	Nathan Lobdell.
	Hope	1790	.....	—— ——
	Indian Lake	1834	1849	Wing Lumber Co.
	Lake Pleasant	1795	1795	—— Foster.
	Long Lake	1830	1836	E. H. St. John.[a]
	Morehouse	1833	1833	Andrew K. Morehouse.
	Wells	1798	1829	Halsey Rogers.
Herkimer	Danube	1730	1799	Samuel Haupt.
	Fairfield	1770	.....	Samuel Green.
	Frankfort	1775	1794	John Hollister.
	Litchfield	1789	1806	—— Talcott.
	Newport	1791	1793	Benjamin Bowen.
	Norway	1786	1793	Capt. David Hinman.
	Russia	1792	1797	Benjamin Hinman.
	Stark (now Starkville)	1775	1776	Abraham Van Horne.
	Webb[b]	1799	1800	Governor John Brown.
	Wilmurt	1790	1790	Arthur Noble.
	Winfield	1792	1795	Joseph Walker.
Jefferson	Adams	1800	1802	David Smith.
	Antwerp	1803	1806	Silas Ward.
	Brownville	1799	1800	Gen. Jacob Brown.
	Champion	1797	1799	Joel Mix.
	Clayton	1802	1804	Smith & Delamater.
	Ellisburg	1797	1797	Lyman Ellis.
	Henderson	1799	1807	Willis Fellows.
	Hounsfield	1800	1802	Augustus Sacket.
	Le Ray	1801	1802	Benjamin Brown.
	Lorraine	1802	1804	—— Frost.
	Lyme	1801	1803	—— ——.
	Orleans	1806	1816	Dr. Andrus.
	Philadelphia	1804	1805	Thos. & John Townsend
	Rodman	1801	1804	William Rice.
	Rutland	1799	1802	David Coffeen.
	Theresa	1810	1810	James D. Le Ray.
Lewis	Croghan	1828	1830	Somerville Stewart.
	Denmark	1800	1801	Nathan Munger.
	Diana	1830	1833	Faskit Harris.
	High Market	1814	.....	James McVicker.
	Lewis	1799	1800	Joel Jenks.
	Leyden	1794	1795	Bela Butterfield.
	Lowville	1797	1798	Daniel Kelley.
	Martinsburg	1801	1803	Walter Martin.

[a] He built it for a landowner named Hammond, receiving a stated sum of money and five lots of land (800 acres?). Under the terms of the contract, he also cut out the first road from Newcomb to Long Lake.

[b] This mill was built at Old Forge by Governor John Brown, of Providence, R. I., the owner of Brown's Tract in the Adirondacks.

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
Lewis	Montague	1846	1848	S. P. Sears.
	New Bremen	1821	1826	Charles Dayan.
	Osceola	1838	1841	William Roberts.
	Turin	1797	1799	Eleazer House.
	Watson	1800	1801	Isaac Puffer.
	West Turin	1795	1796	Nathaniel Shaler.
Livingston	Avon	1785	1790	Timothy Hosmer.
	Conesus	1794	1804	—— ——.
	Leicester	1789	1792	Ebenezer Allen.
	Lima	1788	1796	Reuben Thayer.
	Livonia	1792	1795	—— Higby.
	North Dansville	1795	1796	David Scholl.
	Nunda	1806	1818	Willoughby Lovell.
	Ossian	1804	1809	Nathaniel Porter.
	Portage	1810	1816	Russel Messenger.
	Springwater	1807	1809	Samuel Hines.
Madison	Cazenovia	1793	1794	John Lincklaen.
	De Ruyter	1793	1807	Joseph Rich.
	Eaton	1793	1795	Joshua Leland.
	Georgetown	1804	1806	Mitchell Atwood.
	Lebanon	1792	.....	Elisha Wheeler.
	Madison	1793	1793	Henry W. Bond.
	Nelson	1794	1800	Jeremiah Clark.
	Smithville	1795	1801	Peter Smith.
	Stockbridge	1791	1794	Stockbridge Indians.
	Sullivan	1790	.....	John G. Moyer.
Monroe	Greece	1792	1810	Nathaniel Jones
	Henrietta	1806	.....	Jonathan Smith.
	Ogden	1802	1811	William H. Spencer.
	Parma	1794	1811	Jonathan Whitney.
	Penfield	1801	.....	Daniel Penfield.
	Riga	1805	1808	Samuel Church.
	Webster	1805	1806	Caleb Lyon.
	Wheatland	1789	1810	Peter Shaeffer, jr.
ontgomery	Amsterdam	1716	1742	Sir Wm. Johnson.
	Canajoharie	1770	1770	Col. Hendrick Frey.
	Charleston	1737	1785	Judah Burton.
	Florida	1710	1750	Philip Frederick.
	Glen	1705	1790	Peter Quackenboss.
	Minden	1750	1740	—— Fox.
	Root	1770	.....	Solomon Hamilton.
New York	Manhattan	1614	1633	West India Co.
Niagara	Cambria	1800	1806	Joseph Hewett.
	Lewiston	1800	1808	Joseph Howell.
	Newfane	1807	1811	James Van Horn.
	Porter	1803	1816	John Clapsaddle.
	Royalton	1803	1817	Gad Warner.
	Somerset	1810	1822	John Randolph.
	Wheatfield	1802	1825	Col. John Sweeney.
	Wilson	1810	1815	Daniel Sheldon.
Oneida	Augusta	1793	1795	T. Cassaty.
	Ava	1798	1801	Benjamin Jones.
	Boonville	1795	1796	Holland Land Co.
	Bridgewater	1788	.....	Major Farwell.
	Camden	1796	1798	Jesse Curtis.

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
Oneida	Lee	1790	1796	David Smith.
	Manchester	1787	1788	Captain Casey.
	Marcy	1793	1825	John F. Allen.
	Vienna [a]	1798	1801	Ambrose Jones.
	Westmoreland	1786	1790	Jonathan Dean.[b]
Onondaga	Camillus	1790	1806	Munro & Wheeler.
	Cicero	1790	1823	Freeman Hotchkiss.
	Clay	1793	1811	Abraham Young.
	Dewitt	1789	1792	Asa Danforth.
	Elbridge	1793	1797	William Stevens.
	Fabius	1794	1800	Thomas Miles.
	Geddes	1794	1825	Noah Smith.
	Lafayette	1791	1795	James Sherman.
	Lysander	1793	1807	Dr. Jonas C. Baldwin.
	Manlius	1790	1793	Elijah Phillips.
	Marcellus	1794	1796	Bradley & Rice.
	Onondaga	1787	1793	Turner Fenner.
	Pompey Hill	1792	1796	Pratt & Smith.
	Skaneateles	1793	1796	Jedediah Sanger.
	Spafford	1794	1810	Josiah Walker.
	Tully	1795	1810	Peter Van Camp.
	Van Buren	1792	.....	Skeels & Paddock.
Ontario	Canadice	1807	.....	John Algur.
	East Bloomfield	1789	1790	General Fellows.
	Farmington	1789	1795	Smith Bros.
	Gorham	1789	1807	Buckley & Craft.
	Naples	1790	1792	Clark & Metcalf.
	Phelps	1789	1795	Seth Dean.
	Richmond	1789	1795	Thomas Morris.
	Seneca	1787	1793	P. B. Wisner.
	South Bristol	1789	1795	Gamaliel Wilder.
	Victor	1789	1792	E. & J. Boughton.
	West Bloomfield	1789	1798	Ebenezer Curtis.
Orange	Chester	1751	1810	Richard Bull.
	Crawford	1740	1751	Johannes Snyder.
	Montgomery	1722	1768	Robert Milliken.
	Newburgh	1709	1784	Capt. Thomas Machin.
	New Windsor	1685	1728	Samuel Hazard.
	Wallkill	1767	1776	—— Carpenter.
	Warwick	1719	1760	Daniel Burt.
	Wawayanda	1738	1760	Isaac Finch.
Orleans	Barre	1811	1816	William White.
	Clarendon	1811	1811	Eldridge Farwell.
	Gaines	1808	1813	Henry Drake.
	Kendall	1812	1819	Auger & Boyden.
	Ridgeway	1809	1805	Holland Land Co.
	Shelby	1810	1812	Joseph Ellicott.
Oswego	Albion	1812	1813	Lilly Bros.
	Amboy	1805	1822	Joseph Murphy.
	Boylston	1810	1822	Reuben Snyder.
	Constantia	1790	1795	George Scriba.
	Granby	1792	1814	Schenck & Wilson.

[a] The first death in the town occurred by an accident in a sawmill in 1801, whereby Alex Graves was killed.

[b] A MS. account of Indian mythology written by Mr. Dean is in the State Library, Albany, N. Y.

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
Oswego	Hannibal	1802	1811	Silas Crandell.
	Mexico	1798	.....	George Scriba.
	New Haven	1798	1805	Ira Foot.
	Orwell	1806	1810	Joseph Watson.
	Palermo	1806	1812	Phineas Chapin.
	Parish	1804	1807	Way & Allen.
	Redfield	1798	1801	—— ——.
	Richland	1801	1806	John Hoar.
	Sandy Creek	1804	1805	William Skinner.
	Schroeppel	1800	1819	H. W. Schroeppel.
	Volney	1793	1796	—— Goodell.
	Williamstown	1801	1803	Isaac Alden.
Ostego	Maryland	1793	1795	Jotham Houghton.
	Middlefield	1775	1775	Alexander McCollum.
	Milford	1770	1792	Matthew Cully.
	Roseboom	1800	1806	Abram Roseboom.
	Springfield	1762	1775	Garret Staats.
	Westford	1790	1796	Artemas Howe.
	Worcester	1789	1791	Silas Crippen.
Putnam	Carmel	1739	1750	—— Kellogg.
	Kent	1754	1783	Elisha Cole.
	Phillipstown	1730	1762	Col. Beverly Robinson.
	Putnam Valley	1740	1785	Isaac Post.
	Southeast	1730	1740	Col. Jonathan Crane.
Queens	Jamaica	1656	1675	Joseph Carpenter.[a]
	Oyster Bay	1653	1673	Henry Townsend.[b]
Rensselaer	Berlin	1765	1780	Amos Sweet.
	Grafton	1786	1799	Josiah Litchfield.
	Sandlake	1766	1791	Solomon Taylor.
	Stephentown	1765	1800	—— Younglove.
	Troy City	1659	1663	Jan Barentson Wemp.
Richmond	Castleton	1640	1669	John Palmer.
Rockland	Ramapo	1740	1795	John Suffern.
St. Lawrence	Brasher	1814	1815	G. B. R. Gove.
	Canton	1800	1802	Stillman Foote.
	Colton	1824	1825	Horace Garfield.
	De Kalb	1803	1809	Charles Boreland.
	Edwards	1812	1824	Job Winslow.
	Fine	1823	1828	James C. Haile.
	Fowler	1807	1808	James Haile.
	Gouverneur	1806	1809	Lewis R. Morris.
	Hermon	1812	1818	Milton Johnson.
	Hopkinton	1803	1824	Isaac R. Hopkins.
	Lawrence	1807	1809	Ephraim Martin.
	Lisbon	1800	1804	D. W. Church.
	Louisville	1800	1805	Asa Day.
	Macomb	1817	1818	Timothy Pope.

[a] Joseph Carpenter and Caleb Carman entered into an agreement with the town, whereby they were permitted to use timber from the common lands, "except clapboard and rayle trees under 18 inches," and were to saw for the town "twelve pens in the hundred cheaper than any other persons of any other town"; and for citizens of the town "that bringeth the timber, one-halfe of the sawn stuff for their laboure, provided that it is only for their owne use."

[b] For building this mill the town granted to Townsend and his heirs forever the right to cut and use timber from any part of the town he should choose; also the right to sell such timber either in the town or out of it.

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
St. Lawrence	Madrid	1801	1803	Seth Roberts.
	Massena	1792	1792	Amable Foucher.
	Norfolk	1809	1810	Timothy W. Osborn.
	Ogdensburg [a]	1749	1751	Father Picquet.
	Oswegatchie	1796	1797	Nathan Ford.
	Parishville	1810	1810	Barnes Brothers.
	Pierrepont	1807	1819	Cox & Dimmick.
	Pitcairn	1824	1828	P. Jenny.
	Potsdam	1803	1803	Benjamin Raymond
	Rossie	1807	1810	D. W. Church.
	Russell	1805	1805	Joel Clark.
	Stockholm	1802	1804	Samuel Reynolds.
Saratoga	Charlton	1774	1783	John Rogers.
	Greenfield (now Greenfield Center)	1784	1789	Gershem Morehouse.
	Hadley	1783	1791	Delane & Hazard.
	Halfmoon	1690	1762	—— ——.
	Northumberland	1775	1777	—— Munroe.
	Providence	1775	1786	—— Corey.
	Wilton	1774	1784	John Laing.
Schenectady [b]				
Schoharie	Broome	1791	1794	Griswold & Wells.
	Cobleskill	1750	1774	Christian Brown.
	Jefferson	1794	1796	Stephen Judd.
	Richmondville	1770		Company of settlers.
	Seward	1754	1773	William Hynds.
	Sharon	1771	1784	John Hutt.
	Summit	1794	1798	—— Van Buren.
	Wright	1771	1783	Zimmer & Becker.
Schuyler	Catharine	1788	1791	Phineas Bowers.
	Cayuta	1798	1816	Jesse D. White.
	Dix	1798	1828	Col. Green Bennett.
	Hector	1790	1795	Reuben Smith.
	Orange	1802		Wm. Conlogue.
	Reading	1790		Eliadia Parker.
	Tyrone	1799	1801	—— ——.
Seneca	Fayette	1789	1797	Samuel Bear.
	Seneca Falls	1787	1795	Wilhelmus Mynderse.
	Tyre	1794	1807	Nicholas Traver.
Steuben	Addison	1791	1793	George Goodhue.
	Avoca	1800	1809	Henry Kennedy.
	Bath	1793	1793	Chas. Williamson.
	Bradford	1793	1795	Frederick Bartles.
	Cameron	1800	1808	Richard Hadley.
	Campbell	1800	1807	Campbell & Stephens.

[a] In an official report made to the Canadian Parliament in 1851, entitled "Titles and documents relating to the seignorial tenure," there is a copy of the grant made to Abbé Picquet giving permission to build a sawmill. This concession, signed by François Bigot, the intendant at Quebec, states "that for the usefulness of the said mill it is necessary that there should be attached thereto a tract of land on which to receive the saw logs as well as the boards and other lumber," and grants for this purpose "land of one arpent and a half in front by the same depth." This land now forms part of the city of Ogdensburg.

[b] The colonial patent of 1684, embracing lands in this county and the present site of the city of Schenectady, refers to sawmills which had already been built within the territory granted; but nothing appears now in the town and county records to show when or by whom they were erected.

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
Steuben	Caton	1819	1822	Abner Gilbert.
	Cohocton	1796	1808	Jonas Cleland.
	Corning	1788	1793	Ichabod Patterson.
	Dansville	1804	1816	Robert Fuller.
	Erwin	1787	1820	Samuel Erwin.
	Fremont	1812	1816	Daniel Upson.
	Hartsville	1809	1827	Daniel P. Carpenter.
	Horuby	1814	1824	Levi Nash.
	Hornellsville	1792	1795	George Hornell.
	Howard	1806	1810	Henry Kennedy.
	Jasper	1807	1811	Nicholas Prutsman.
	Lindley	1790	1793	Eleazer Lindley.
	Pultney	1802	1810	Melchior Wagener.
	Rathbone	1794	1812	Isaac Tracy.
	Thurston	1813	1814	Paris Wheelock.
	Tuscarora	1801	1806	William Wombaugh.
	Urbana	1793	1795	John Shether.
	Wayland	1806	1815	Benjamin Perkins.
	West Union	1822	1849	John Wiley.
	Wheeler	1799	1802	Silas Wheeler.
	Woodhull	1805	1806	Caleb Smith.
Suffolk	Huntington	1653	1688	Jonathan Rogers.[a]
	Riverhead	1690	1659	John Tucker.[b]
	Smithtown	1650	1789	George Phillips.
	Southold	1640	1659	John Tucker.
Sullivan[c]	Bethel	1798	1805	John K. Beeman.
	Callicoon	1814	.....	Jacob Quick.
	Fallsburgh	1788	1795	William A. Thompson.
	Forestburgh	1783	1783	Capt. A. Cuddeback.
	Fremont	1780	1792	Aaron Pierce.
	Highland	1825	.....	N. Patterson.
	Liberty[d]	1790	1799	Capt. Chas. Brodhead.
	Mamakating	1728	1730	Manuel Gonsaulus.
	Thompson	1749	1795	William A. Thompson.
	Tusten	1763	1760	John Moore.
Tioga	Barton	1787	1803	George W. Buttson.
	Berkshire	1791	1810	Bull & Brown.
	Candor	1785	1829	Orange F. Booth.
	Newark Valley	1791	[e]1830	Patterson & Day.
	Nichols	1787	[e]1833	George Kirby.
	Owego	1785	1826	Willard Foster.
	Richford	1809	1818	Caleb Arnold.
	Spencer	1794	1800	Edmund Hobart.
	Tioga	1789	1792	Maj. Wm. Ransom.

[a] Rogers was granted permission to build a sawmill at Cold Spring on condition that he furnish lumber at a certain price "and deliver up the stream when the town wants it for a gristmill."

[b] In 1659 John Tucker "propounded for liberty to sett up a sawmill neere the head of the river, and liberty to cut all sorts of timber, but noe more of oake than fell in the common track of getting pine and cedar which were the chief inducements of getting a mill there to saw."

[c] Charles Webb, who made a survey of the Minnisink patent in 1762, makes mention in his field notes of Reeves's sawmill.

[d] This mill, which stood on the outlet of Brodhead Pond, was built wholly of logs and hewed timber. The race was constructed from large hemlock trees "with much labor and ingenuity."

[e] Steam mill. There may have been a water mill in the town before this was built; but if so there is nothing in the town records to indicate it.

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
Tompkins	Caroline	1795	1800	Gen. John Cantine.
	Danby	1795	1797	Dumond & Yaple.
	Dryden	1797	1800	Ruloff Whiting.
	Enfield	1804	1812	Benjamin Ferris.
	Groton	1798	1811	Jonas Williams.
	Ithaca	1789	1813	Phineas Bennett.
	Newfield	1801	1809	Eliakim Dean.
	Ulysses	1791	1796	David Atwater.
Ulster	Denning	1821	1827	Dewitt & Reynolds.
	Gardiner	1724	1794	James Jenkins.
	Hardenburgh	1800	1860	Hiram Seager.
	Kingston	1650	1847	Peter J. Du Bois.
	Marlborough (now Marlboro)	1772	1780	James Hallock.
	Olive	1740	1765	Lemuel Winchell.
	Plattekill	1780	1800	Andrew Garrison.
	Rochester	1688	1703	—— ——.
	Saugerties	1710	1800	Hendriek Schoonmaker.
	Shandaken	1800	1860	D. C. Dutcher.
	Shawangunk	1680	.....	—— Harris.
	Woodstoek	1770	1820	Robert Livingston.
Warren	Bolton	1792	1813	William H. Oglesva.
	Chester	1789	1790	Jabez Mead.
	Johnsburg	1784	1790	John Thurman.
	Queensbury	1762	1764	Moses Clements.
	Stony Creek	1795	1825	James McDonald.
	Thurman	1799	1815	Caleb Reynolds.
	Warrensburgh	1784	1794	Jonathan Vowers.
Washington	Cambridge	1762	.....	Philip Van Ness.
	Dresden	1784	1815	Amos Collins.
	Easton	1762	1768	Nathan Tefft.
	Fort Ann	1781	1788	Jacob Van Wormer.
	Fort Edward	1764	.....	William Duer.
	Granville	1772	1787	Nathaniel Spring.
	Greenwich	1766	1773	Daniel Rose.
	Hebron	1770	.....	William Lytle.
	Kingsbury	1764	1768	Albert Baker.
	Putnam	1784	1802	Robert Cummings.
	White Creek	1765	1790	Hercules Riee.
	Whitehall	1761	1766	Col. Philip Skene.
Wayne	Areadia	1791	1801	Joseph Caldwell.
	Butler	1803	1819	Jacob S. Viele.
	Galen	1800	1810	Thomas Beadle.
	Huron	1796	1809	Elihu Spencer.
	Lyons	1789	1880	John Perrine.
	Ontario	1806	1811	Freeman Hopkins.
	Palmyra	1790	1795	Joel Foster.
	Rose	1805	1811	Elijah Howe.
	Savannah[a]	1808	1824	Royal Torrey.
	Sodus	1795	1800	Captain Williamson.
	Williamson	1803	1806	Jeremiah Selby.
	Wolcott	1807	1813	Elisha Plank.

[a] The stream Crusol Creek, upon which the first sawmill was built, diminished as the forests about its sources disappeared, so that in about twenty years the mill lost its power. There is now no water-power afforded by any stream in the town.

The beginnings of the lumber industry in the State of New York—Continued.

County.	Town.	First settlement.	First sawmill.	Built by—
Westchester	Scarsdale	1701	1668	William Saxton.
Wyoming	Arcade	1808	1811	Maj. Moses Smith.
	Bennington	1802	1808	Chauncey Loomis.
	Castile	1808	1811	Robert Whalley.
	Covington	1807	1812	Sprague & Spaulding.
	Eagle	1808	1811	Amos Huntley.
	Gainesville	1805	1809	Wheelock Wood.
	Genesee Falls	1804	1815	Mumford, Smith & McKay.
	Middlebury	1802	1809	A. Worden.
	Orangeville	1805	1810	Robert Hopkins.
	Pike	1806	1809	Eli Griffith.
	Sheldon	1804	1806	William Vary.
	Wethersfield	1810	1812	Calvin Clifford.
Yates	Barrington	1800	1806	William Cummins.
	Benton	1789	1790	Dr. Caleb Benton.
	Italy	1793	1795	Asahel Stone, jr.
	Jerusalem	1789	1795	Daniel Brown.
	Middlesex	1789	.....	John Walford, jr.
	Potter	1788	1792	Arnold Potter.
	Starkey	1800	1807	Timothy Hurd.

LIST OF BULLETINS HERETOFORE PUBLISHED BY THE DIVISION (NOW BUREAU) OF FORESTRY.

[Publications to which prices are affixed may be obtained from the Superintendent of Documents, Union Building, Washington, D. C. Numbers marked thus * are out of print.]

*No. 1. Report on the Relation of Railroads to Forest Supplies and Forestry. M. G. Kern. (Appendixes by others.) 1887.
*No. 2. Report on the Forest Conditions of the Rocky Mountains, with map showing location of forest areas. Col. Edgar T. Ensign. (Includes other papers.) 1889.
*No. 3. Preliminary Report on the Use of Metal Track on Railways as a Substitute for Wooden Ties. E. E. Russell Tratman, C. E. (Includes other matter.) 1889.
*No. 4. Report on the Substitution of Metal for Wood in Railroad Ties. E. E. Russell Tratman, C. E. (Discussion.) 1890.
*No. 5. What is Forestry? B. E. Fernow, Chief of the Division of Forestry. 1891.
No. 6. Timber Physics. Part I. Preliminary Report. B. E. Fernow. 1892. 10 cents.
No. 7. Forest Influences: Meteorological Observations. M. W. Harrington. Relation of Forests to Water Supply. B. E. Fernow. Sanitary Significance of Forests. B. E. Fernow. (Appendixes.) 1893. 15 cents.
No. 8. Timber Physics. Part II. Progress Report. (Contains reports of various authors.) 1893.
No. 9. Report on the Use of Metal Railroad Ties, and on Preservative Processes. E. E. Russell Tratman, C. E. 1894.
No. 10. Timber: Characteristics and Properties of Wood. Filibert Roth. 1895.
*No. 11. Some Foreign Trees for the Southern United States. (Sundry papers by different authors.) 1895.
No. 12. Economical Designing of Timber Trestle Bridges. A. L. Johnson, C. E. 1896. 5 cents.
No. 13. The Timber Pines of the Southern United States. Charles Mohr, Ph. D. With discussion of the structure of their wood by Filibert Roth. 1897. 35 cents.
*No. 14. Nomenclature of the Arborescent Flora of the United States. George B. Sudworth. 1897.
*No. 15. Forest Growth and Sheep Grazing in the Cascade Mountains of Oregon. Frederick V. Colville. 1898.
No. 16. Forestry Conditions and Interests of Wisconsin. Filibert Roth. 1898. 10 cents.
No. 17. Check List of the Forest Trees of the United States. George B. Sudworth, Dendrologist. 1898. 15 cents.
*No. 18. Experimental Tree Planting in the Plains. Charles A. Keffer. 1898.
No. 19. Osier Culture. John M. Simpson. 1898. 5 cents.
No. 20. Measuring the Forest Crop. A. K. Mlodziansky. 1898. 10 cents.
No. 21. Systematic Plant Introduction. David G. Fairchild. 1898. 5 cents.
No. 22. The White Pine. V. M. Spaulding. (Revised and supplemented.) 1899. 40 cents.
No. 23. (Not yet published.)
No. 24. A Primer of Forestry. Part I. The Forest. Gifford Pinchot, Forester. 1899, 1900. 35 cents.
*No. 25. Notes on the Forest Condition of Porto Rico. Robert T. Hill, Geologist, U. S. Geological Survey. 1899.
No. 26. Practical Forestry in the Adirondacks. Henry S. Graves. 1899. 15 cents.
No. 27. Practical Tree Planting in Operation. J. W. Toumey. 1900. 5 cents.
No. 28. A Short Account of the Big Trees of California. 1900. 15 cents.
No. 29. The Forest Nursery: Collection of Tree Seeds and Propagation of Seedlings. George B. Sudworth. 1900. 10 cents.
No. 30. A Forest Working Plan for Township 40, New York State Forest Preserve. Ralph S. Hosmer and Eugene S. Bruce. With discussion of lumbering and water supply by Frederick H. Newell, Hydrographer, U. S. Geological Survey. 1901. 25 cents.

LIST OF BULLETINS PUBLISHED BY THE BUREAU OF FORESTRY.

No. 31. Notes on the Red Cedar. Dr. Charles Mohr. 1901. 10 cents.
No. 32. Working Plan for Forest Lands near Pine Bluff, Arkansas. F. E. Olmsted. 1902. 15 cents.
No. 33. The Western Hemlock. E. T. Allen. 1902.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF FORESTRY—BULLETIN No. 35.

GIFFORD PINCHOT, Forester.

EUCALYPTS CULTIVATED IN THE UNITED STATES.

BY

ALFRED JAMES McCLATCHIE, M. A.,

Agriculturist and Horticulturist of the Arizona Experiment Station, Phoenix, Arizona.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1902.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF FORESTRY—BULLETIN No. 35.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Forestry,
Washington, D. C., June 4, 1902.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 35 of the Bureau of Forestry, a report entitled "Eucalypts Cultivated in the United States," by Prof. A. J. McClatchie, agriculturist and horticulturist of the Arizona Experiment Station, Phoenix, Ariz. Professor McClatchie has had excellent opportunities for studying the Australian Eucalypts, which are now extensively grown in the Southwest for ornament, for wind-breaks, and for their useful timber. The phenomenally rapid growth of the Eucalypts, and the special adaptation of many species to dry climates, render these trees of peculiar economic importance to the Southwest. The descriptions and illustrations of species, with the information upon their requirements of soil and climate, and upon the character and uses of their wood, together form a practical guide for the tree planter.

Very respectfully,

Gifford Pinchot,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

INTRODUCTION.

The Eucalypts are now grown in America, especially in the Southwestern United States, more extensively than any other exotic forest tree. During the past forty years they have been planted here and in other parts of the world for ornament, for sanitary improvement, for shade, for wind-breaks, for fuel, for oil, and for timber; and incidentally they have been useful in many other ways. In fact, they have probably served more æsthetic and utilitarian purposes than any other forest trees that have been planted on this continent.

These trees have been studied and extolled alike by botanists, gardeners, and foresters. They are worthy of all the attention that has been given them and deserve to be still better known. The late Baron Ferdinand von Mueller, Government botanist of Victoria, Australia, the most renowned student of the great Australian genus Eucalyptus, prophesied in his scholarly Eucalyptographia that "The Eucalypts are destined to play a prominent part for all times to come in the silvan culture of vast tracts of the globe; and for hard-wood supplies, for sanitary measures, and for beneficent climatic changes all countries within the warmer zones will with appreciative extensiveness have to rely on our Eucalypts during an as yet uncountable period." All who have lived where Eucalypts grow can realize fully the force of the prophecy and the great value of the genus to mankind, both present and prospective.

In the following pages the Eucalypts are viewed mainly from the standpoint of their usefulness, only incidentally being treated as ornamentals. No attempt is made to present an exhaustive botanical treatise of the Eucalypts. The botanical features introduced are intended to be subservient to the interests and purposes of the forester.

Only the large arboreal species are discussed—that is, species attaining a height of over 40 to 50 feet and a diameter of over 1 foot. Many of the species consisting of smaller trees are very interesting to the botanist and gardener, but they are of comparatively little interest to the forester.

This publication is not a general treatise on the genus Eucalyptus,

but has to do more especially with the genus as it behaves in North America. Only those species that have fruited and by this means have been identified are treated. This treatise is based mainly upon ten years' observation and study of the genus in California and Arizona and three years of experimental work in the latter region. Besides the data obtained as a result of this personal work, very much of value concerning the genus has been learned through correspondence with students and growers of Eucalypts in the various regions where they grow naturally or have been introduced. In this connection I wish to acknowledge especial indebtedness to the following persons for valuable assistance rendered: Hon. Abbot Kinney, Los Angeles; Hon. Ellwood Cooper, Santa Barbara; Mr. J. H. Maiden, F. L. S., government botanist, Sydney, Australia; Mr. F. Manson Bailey, F. L. S., colonial botanist, Brisbane, Australia; Prof. L. Trabut, Alger-Mustapha, Algiers; E. R. Holmes, Paris; Nathan W. Blanchard, Santa Paula, Cal.; and Col. G. H. Norton and A. K. Sanders, Eustis, Fla.

The purpose of this bulletin is to give information concerning the characteristics of the Eucalypts, their climatic requirements, and their uses; to give directions and suggestions as to their propagation and culture; and to furnish a means of identifying seedlings and mature trees, so that as the Eucalypts growing throughout the Southwest become identified, such trees may become sources of information concerning the species they represent, and sources of seed for propagation. This Australian group of trees now serves very many useful purposes in the Southwest, and gives promise of great future usefulness in the semiarid portions of our continent. It is believed that when the merits of these trees are fully understood, and information concerning their climatic requirements and their propagation is readily available, they will be planted more extensively and with increasing intelligence and discrimination. The covering of the now untillable, treeless portions of the semitropic section of America with such trees as Eucalypts, which will yield fuel, timber, and other useful products, and also furnish protection from the sun, from winds, and from floods, or otherwise ameliorate existing climatic conditions, is certainly an achievement greatly to be desired.

The illustrations are from photographs made by the writer during the past six years. Photographs of most of the seedlings in pots were made at a nursery in South Pasadena, Cal., the proprietors of which were extensive American growers of Eucalypts. The remainder were taken at the experiment station farm near Phoenix, Ariz. Seedlings 4 to 8 months old, as nearly typical of the respective species as possible, were selected for subjects. It is believed that these illustrations will prove useful to growers and purchasers in identifying seedlings of these

trees. The photographs of the branches bearing leaves, buds, flowers, and seed cases were taken in each instance from a specimen fastened to the trunk of the tree upon which it had grown, by this means showing fairly well the nature of the bark of the tree. It is thus attempted in each of these latter photographs to illustrate the principal features upon which the species are based, and it is hoped that they will be found helpful in identifying trees the names of which are unknown or doubtful.

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EUCALYPTS CULTIVATED IN THE UNITED STATES.

PART I.

THE NATIVE HOME OF THE EUCALYPTS.

The native home of the Eucalypts is Australia and some of the adjacent islands, including Tasmania, New Guinea, Timor, and one of the Moluccas. All but a very small per cent of the species are found on the continent of Australia itself. A small number grow both on Tasmania and in Australia, one of these being the Blue Gum, *Eucalyptus globulus*, the species that has been cultivated most widely throughout other parts of the world.

The Eucalypts constitute a considerable part of the forests of Australia, and are said to give a characteristic appearance to the landscape of the regions in which they grow. They are known in their native home as Gum trees, Mahogany trees, Box trees, Stringy barks, and by quite a number of other names, the first being the most common appellation. Notwithstanding the general use of the term "Gum tree," the name is not an entirely appropriate one, as the exudations from the trees are in most cases not gums, but resins. The name "Eucalypts," proposed by Baron von Mueller, and used in this publication, is more suitable and euphonious. The only Australian common names that have been generally adopted in America are "Blue Gum tree" for *E. globulus*, and "Red Gum tree" for *E. rostrata* and several other species, indiscriminately. In Australia several species are known as Blue Gums and several as Red Gums. This confusion of names, due to the great number of the species, and to the application to the same species of different common names by the inhabitants of the various colonies of Australia, makes it impracticable to designate a Eucalyptus tree by a common name. For distinctness it is necessary to use the botanical names almost entirely. It will probably be some time, even in their native home, before these trees have well established popular names for each of the 150 or more species.

In Australia the different species occupy situations varying from deserts or dry mountainous regions to low, swampy, and moist mountainous ones. On account of the great diversity of species and their wide distribution in their native home, it has been possible to select

species suitable to a great variety of semitropic situations; and there are undoubtedly greater future possibilities along this line. Each year one or more additional promising species finds its way from Australia to our continent, the usefulness of the genus being thus continually extended to new regions. As Americans become better acquainted with the Eucalypts in their native home the possibilities for the usefulness of these trees upon our continent will be increased.

THE EUCALYPTS AS EXOTICS.

INTRODUCTION OVER THE GLOBE.

From Australia the Eucalypts have been carried to many parts of the earth having a similar climate. The dissemination began on an extensive scale about the middle of the past century, largely through the labors of Baron von Mueller in Australia and of M. Ramel in Australia and in Europe. To be sure, small plantings had been made in Europe and in Africa earlier in the century, but we are indebted to these men for an adequate appreciation of the real merits of the genus. Prof. J. E. Planchon, one of the students and disseminators of Eucalypts in France, says of these men in his paper upon the *Eucalyptus globulus*,[a] that their memory should be associated with the name Eucalyptus "wherever this tree thrives as a source of public wealth and salubrity;" and then adds:

> In the history of the future naturalization of the Eucalyptus, Mueller is the savant who justly calculated the future of the tree, traced it in its [prospective] itineracy, and predicted its destiny. Ramel is the enthusiastic amateur who has thrown body and mind into the mission of propagating it. Both have faith, but one is a prophet, the other an apostle; and, in the noble confraternity of services, public gratitude will not separate the names that are bound together by friendship.

Others took up the good work in various parts of the world, and, during the quarter of a century that followed, the genus became widely distributed. It is said that more trees of this genus have been planted away from its original habitat than of all other forest trees combined. As an indication of how extensively they were being planted a quarter of a century ago, the following statement from a seed catalogue published in Sidney in 1875 is of interest:

> To give our friends some idea of the demand: We have sold nearly half a ton of seed during the past year. One pound weight should produce many thousand plants.

The present generation is reaping the benefit of the extensive planting of that period.

The Eucalypts are now grown successfully in southern Europe, in northern and in southern Africa, in southern Asia, in parts of South America, and in the Southern part of North America. Thus, a por-

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[a] Revue des Deux Mondes, January, 1875. Translated and published by Department of Agriculture, May, 1875.

tion of each continent of the globe is receiving the benefit of the distribution of this useful genus from its native home. In many of the above regions the Eucalypts are a conspicuous feature of the country, the aspect of the landscape having in some cases been completely changed by the planting of these trees. There are undoubtedly many other parts of the earth yet to be benefited by the introduction and extensive planting of species adapted to the climatic conditions. The tests of various species made in Arizona by the writer, during the past three years, indicate that there are species of Eucalypts adapted to many regions where they have not been tried. These experiments indicate also that in localities where it has been supposed they could not be grown successfully as forest trees suitable varieties have not been tried. There is need of a careful study of these trees in their native habitats, in order to determine what species may be introduced into regions with climate and soil similar to those of the districts in which the respective species grow naturally.

IN SOUTHERN EUROPE.

According to Baron von Mueller Eucalypts were first planted in Europe in the botanic garden of Naples, in the early part of the last century. But their value as forest trees was not recognized anywhere in southern Europe until after the middle of the century, and in Italy not until 1870. During the past forty years their culture has increased rapidly. Claude M. Thomas, American consul at Marseilles in 1894, states, in Consular Reports No. 168, that "the cultivation of the Eucalyptus is receiving much attention from thoughtful men, wherever in Europe climate and soil are of a character adapted to its growth."

The French botanists and gardeners were pioneers in studying Eucalypts and in distributing them throughout southern Europe. Their interest seems to have continued unabated for nearly half a century, more publications on the culture and uses of the Eucalypts having appeared in the French language in that time than in any other, and probably more than in all other languages in which such treatises have been written. The Eucalypts were introduced into France during or before 1854, and during the succeeding quarter century were planted extensively. Planchon said in 1875:

> Now the entire region from Cannes to Monaco displays to the traveler * * * the aspiring branches of the Eucalyptus, with their scythe-shaped leaves trembling beneath the slightest breeze, and withstanding the repeated and violent winds from the east.

M. Henri Carreron, in an article in a recent number of the Journal de Genève, makes the following statements concerning the present prevalence of Eucalypts in southeastern France:

> A Provençal who has not seen the Côte d'Azur for the last forty years would not

recognize it, so changed is the aspect of its vegetation. No more there of those characteristic, stunted, grayish bushes. They have been replaced on at least one-fourth of the surface of the land by cooling and fragrant forests of huge Eucalypts, which tower high above the thousand-year-old Olive and Mastic trees. Australia is invading the ancient Provence; the antipodean forest is gradually taking the place of the indigenous species of the Old World.

Felix Sathut states in his Les Eucalyptus, published in 1888, that—

> The Eucalyptus * * * is certainly of all the exotic trees thus transplanted the one which excites the most astonishment by the rapidity of its growth, its gigantic proportions, and the very great diversity of its appearance and foliage. It is already so abundant that it is encountered at every step in the public places, in all the gardens, and it is already being used as a forest sort.

In France, Eucalyptus culture is still confined almost exclusively to the Mediterranean coast region, no species having been generally introduced that will withstand the frosts that occur at most points to the north of this favored maritime district. From that country culture has extended into most of the region about the Mediterranean, including its islands. On the island of Corsica these trees have been grown with special appreciation of their value, several publications having been written concerning their culture there.

In Italy, Eucalypts were grown previous to 1870 simply as botanical or ornamental specimens. During that year they were first set in large numbers for the sanitary improvement of a locality. The most extensive planting made that year was by the Trappist monks at Tres Fontane in the Campagna Romana, where malaria was very prevalent. Charles Belmont Davis, American consul at Florence in 1894, writes, in Consular Reports No. 168, that—

> A few monks used to go to this place from Rome every morning after the sun had cleared away the fog, plant as many of the *Eucalyptus globulus* as they could during the day, and return to the city in the evening. * * * Over 55,000 Eucalyptus trees are planted at this place to-day. * * * At present Italy has at least 100,000 Eucalyptus under successful cultivation, 30,000 of which are due to the railway companies and 70,000 to private enterprise.

According to a report made by Herbert W. Bowen, American consul at Barcelona, in 1894, Eucalypts were introduced into Spain in 1865, where *Eucalyptus globulus* became known as the "fever tree," "because it is believed to purify boggy and aqueous regions that engender fevers." Mr. Bowen writes:

> The French are the most active and intelligent (if we leave our own Californians out of the question) in propagating the tree. Hardly less sanguine than the French are * * * the Spaniards, who hope by cultivating the Eucalyptus to eliminate from the atmosphere the noxious exhalations of their soil, and to secure an ample supply of woodland and wood.

In Portugal and in Greece Eucalypts are grown successfully, but have not yet been planted on so extensive a scale as in other parts of southern Europe.

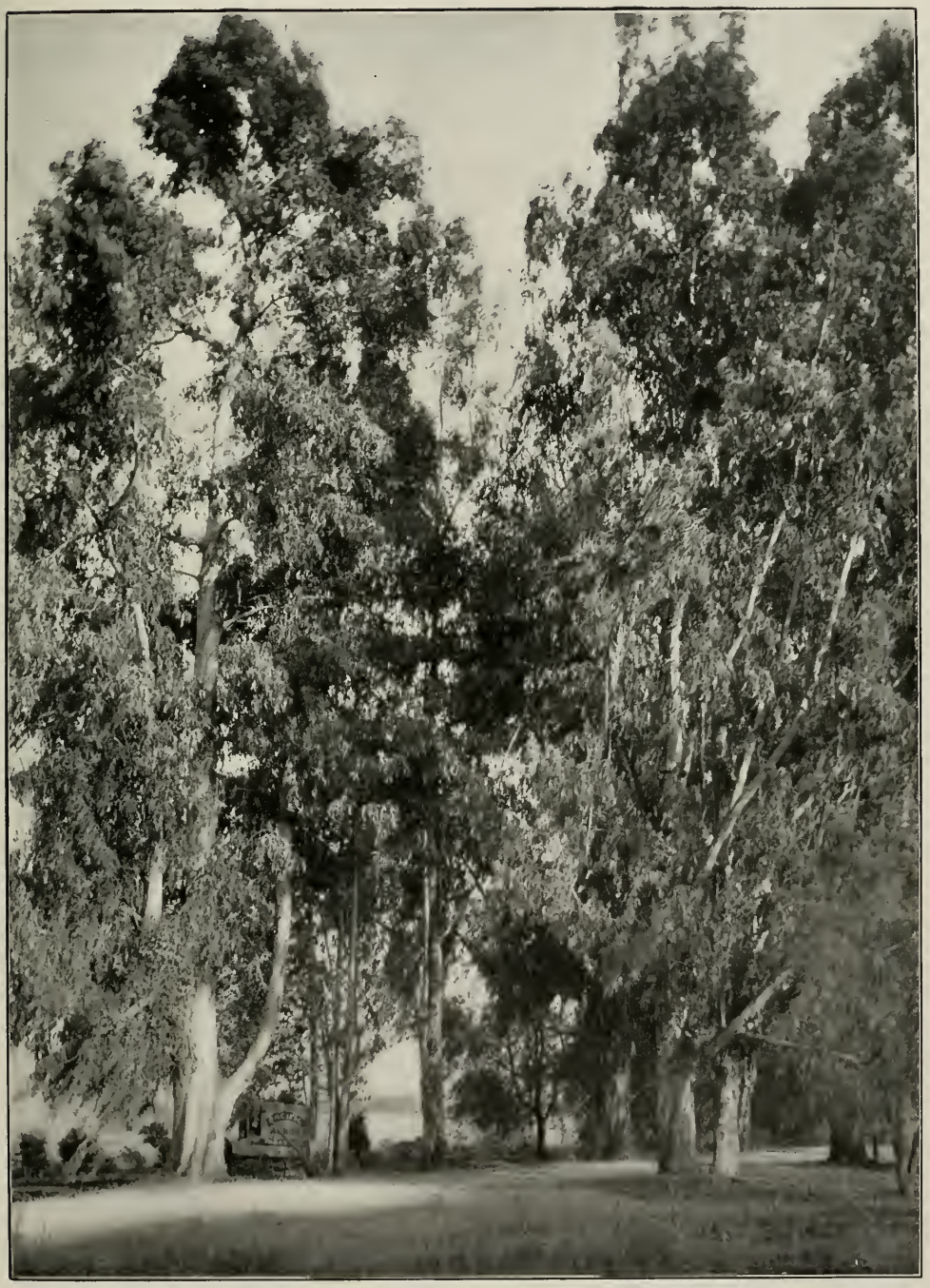
A. EUCALYPTS AS FOREST COVER FOR PARKS, EAST LAKE PARK, LOS ANGELES, CAL.

B. EUCALYPTS AS WIND-BREAKS. EUCALYPTUS GLOBULUS PROTECTING AN ORANGE ORCHARD NEAR LOS ANGELES, CAL.

A. EUCALYPTUS CORNUTA.

B. EUCALYPTUS CÓRYNOCALYX.

EUCALYPTS AS AVENUE SHADE TREES NEAR SANTA MONICA, CAL.



PUBLIC ROAD NEAR ALHAMBRA, CAL.

A. VIEW IN A GROVE 20 YEARS OLD NEAR LOS ANGELES, CAL.

B. CABIN NEAR LOS ANGELES. (EUCALYPTUS VIMINALIS IN FOREGROUND.)

THE BLUE GUM (EUCALYPTUS GLOBULUS) AS A TIMBER TREE.

IN AFRICA.

About the same time that the Eucalypts were introduced into France they were carried into the French colonies in northern Africa. The Blue Gum (*Eucalyptus globulus*) is reported to have been introduced into Algeria in 1854, a little over half a century after the discovery of the species in Tasmania by La Billardière. By the year 1875, according to Planchon, it had been planted in northern Africa "by hundreds of thousands, in groves, in avenues, in groups, in isolated stalks, in every section of three provinces; and the foreigner who does not know the exotic origin of the Eucalyptus would suppose it to be an indigenous tree." He adds: "No tree has in so short a space of time introduced into the forest vegetation of Algeria so picturesque an element, or is as useful and as promising for the future."

Prof. Louis Trabut, Government botanist of Algeria, wrote to the author as follows, under date of October 14, 1900:

> Relative to the Eucalyptus, this tree has been planted in Algeria since 1870. Only *E. globulus* was planted for several years. Lately they have planted *E. rostrata*. These are the only species that have been generally planted. Among amateurs 100 other species may be found. The Eucalyptus has rendered great service to the country in quickly growing wood for the timbers of sheds and other farm buildings.

Eucalyptus culture has continued to spread, now extending throughout other parts of the continent, more especially in the English and Dutch colonies of southern Africa. James Bryce, in his Impressions of South Africa, published in 1897, says, concerning the planting of Eucalypts in the latter region:

> The want of forests in South Africa is one of the greatest misfortunes of the country, for it makes timber costly. * * * Unfortunately, most of the South African trees grow slowly; so where planting has been attempted it is chiefly foreign sorts that are tried. Among these the first place belongs to the Australian gums, because they shoot up faster than any others. One finds them now everywhere, mostly in rows or groups around a house or a hamlet, but sometimes also in regular plantations. They have become a conspicuous feature in the landscape of the veldt plateau, especially in those places where there was no wood, or the little that existed has been destroyed. * * * If this goes on, those Australian immigrants will sensibly affect the aspect of the country, just as they have affected that of the Riviera in southeastern France, of the Campagna of Rome, of the rolling tops of the Nilghiri hills in South India.

IN SOUTHERN ASIA.

It is reported that the Eucalypts were introduced into southern India as early as 1843. Several thousand acres are now covered with these trees, principally upon the Nilghiri and Palui hills. In parts of India a great variety of Eucalypts thrive, while in other sections only a limited number of species can be grown. Some large plantations there are now 40 years old. In the consular report for Sep-

tember, 1894, V. L. Polk, then consul-general at Calcutta, remarks concerning the Blue Gum (*Eucalyptus globulus*): "It may be said generally that the growth of this species is an unqualified success."

IN SOUTH AMERICA.

The Eucalypts have been grown in parts of South America for over thirty years. Interest in them in the Argentine Republic was aroused by the careful work of Dr. Ernest Aberg, who conducted cultural experiments with the genus and in 1874 published a work upon the importance of these trees for a wood supply. They are grown to some extent in Peru, in Venezuela, and in other parts of the continent.

IN NORTH AMERICA.

The Eucalypts were introduced into North America only a few years after their introduction into France and Algeria, the merits of the genus being early recognized by Californians. It is reported that they were introduced into California in 1856 by Mr. Walker, of San Francisco, and in that year 14 species were planted. In 1860 Mr. Stephen Nolan, a pioneer nurseryman of Oakland, being greatly impressed with the rapid growth of these first trees, and also with their evident adaptability to the climate, commissioned a sea captain sailing for Australian ports to secure any Eucalyptus seed he could, at the same time furnishing money with which to make the purchase. A large supply of seed of several species, including *Eucalyptus viminalis*, was received from this source, and sown in 1861. Mr. Nolan continued to import seed in quantity for several years, distributing the seedlings widely through the State.

The country is especially indebted to Hon. Ellwood Cooper for calling attention to the merits of the Eucalypts. For many years he was very active in bringing the genus to the attention of the citizens of California. Under date of May 28, 1900, he writes:

> There were Blue Gum trees growing in the State during my first visit in 1868. I saw a few specimens in private gardens from 10 to 20 feet high; was attracted to their beauty; so that when I located in Santa Barbara, in 1870, I at once conceived the idea of forest planting.

In 1875 he delivered in Santa Barbara a lecture in which his enthusiasm for the genus found expression. This was probably the first address on the subject in America. His interest in these trees (and, incidentally, the rapidity of their growth, which is one of the causes of their rapid introduction) is shown by the following statement made by him upon that occasion:

> At my home I have growing about 50,000 trees. The oldest were transplanted three years ago. A tree three years and two months from the seed, transplanted two years and ten months ago, is 9½ inches in diameter and 42 feet 6 inches high.

During the intervening quarter century Mr. Cooper has continued the extensive planting of Eucalypts. He has set them in canyons and on steep hillsides, has utilized them for a forest cover, for wind-breaks, for shade on avenues, for sources of timber and wood, as well as for ornament, thus furnishing the country an object lesson of what the tree will do for an appreciative planter. He now has about 200 acres of his ranch north of Santa Barbara covered with forests of these trees. Here is the best place in America to see a large variety of Eucalypts grown as forest trees. Several varieties to be seen only as botanical or ornamental specimens elsewhere can be seen here growing by the acre. Mr. Cooper's groves have been and will continue to be valuable sources of information as to the behavior, when growing in forests, of several species not yet generally planted in America.

A great impetus has been given the planting of Eucalypts in the southwestern United States by the labors of Hon. Abbot Kinney, of Los Angeles. As chairman of the California Board of Forestry from 1886 to 1888 he rendered a great service to the State in causing the planting of thousands of Eucalypts within her borders. A large percentage of the trees of species other than *Eucalyptus globulus*, now growing in the Southwest, are from plants distributed during his administration. Mr. Kinney has ever since been an enthusiastic student and planter of trees of this genus, and has written more upon Eucalypts than any other American. In southern California especially, and in Arizona also, the planting of these trees has been extended very much by his work.

During recent years the planting of Eucalypts has been stimulated by the labors of Mr. A. Campbell-Johnston, of Garvanza, Cal., an ardent student and admirer of these trees, who by his writings and his example has done much to attract attention to the merits of the genus. The firm with which he is connected at South Pasadena, Cal., is rendering a service of incalculable value in furnishing for planting authentically named seedling Eucalypts. Mr. Campbell-Johnston is also conducting at his ranch the most extensive cultural test of species of Eucalyptus that has been made in America.

It is through the labors of such men as have been mentioned, and of many others, that the Eucalypts have become disseminated and recognized and very generally planted throughout California. The landscape of many parts of the State has been completely changed by the growth of these trees. Over much of the State they are the principal wind-break, shade, and fuel trees, and the number of useful purposes they serve is continually increasing. Without the Eucalypts California would be a very different State, and their value to the Commonwealth is beyond calculation.

From California the planting of Eucalypts extended into Arizona,

New Mexico, Texas, and Florida. In most cases the Blue Gum (*Eucalyptus globulus*), the species that had been most successfully grown in California, was the one first planted in these regions. The Blue Gum is not adapted to these regions and this has led to the belief that no Eucalypts would thrive there. In southern Arizona, for example, the Blue Gum does not endure the dry heat of summer, while in Florida the frosts of winter have been fatal to it. But in some of these places more resistant species have been introduced and are growing satisfactorily. A more careful and systematic study of the genus, accompanied by cultural tests, will undoubtedly result in the discovery of additional and probably better species for these and other regions.

Eucalypts have been introduced from California into Mexico also, and their merits are being gradually recognized there.

The introduction of heretofore untried species is continuing in the Southwest, and the number grown there is thus rapidly increasing. During the past three or four years especially a great many species have been added to the list of those grown in America. The forty species discussed at length in this publication comprise the species known to the writer that have been introduced long enough to produce seed, and thus establish their identity. Five years hence a large number of additional species will have fruited, and a publication covering the same ground that this one aims to cover would then include nearly twice the number discussed in these pages. The recently introduced species are growing mostly at the University of California, at forestry stations at Santa Monica and Chico, on the ranch of A. Campbell-Johnston (Garvanza), in Elysian Park (Los Angeles), and upon the experiment station farm near Phœnix. Their development is being closely watched by those interested in their planting, and by whom the great future possibilities in these recent arrivals from the native home of the genus is fully realized.

WRITERS UPON EUCALYPTS.

FOREIGN.

Much has been written concerning this very interesting group of trees. Most of the publications have been in English and in French—several score in each language. A few have appeared in Italian, a few in German, and a few in Spanish.

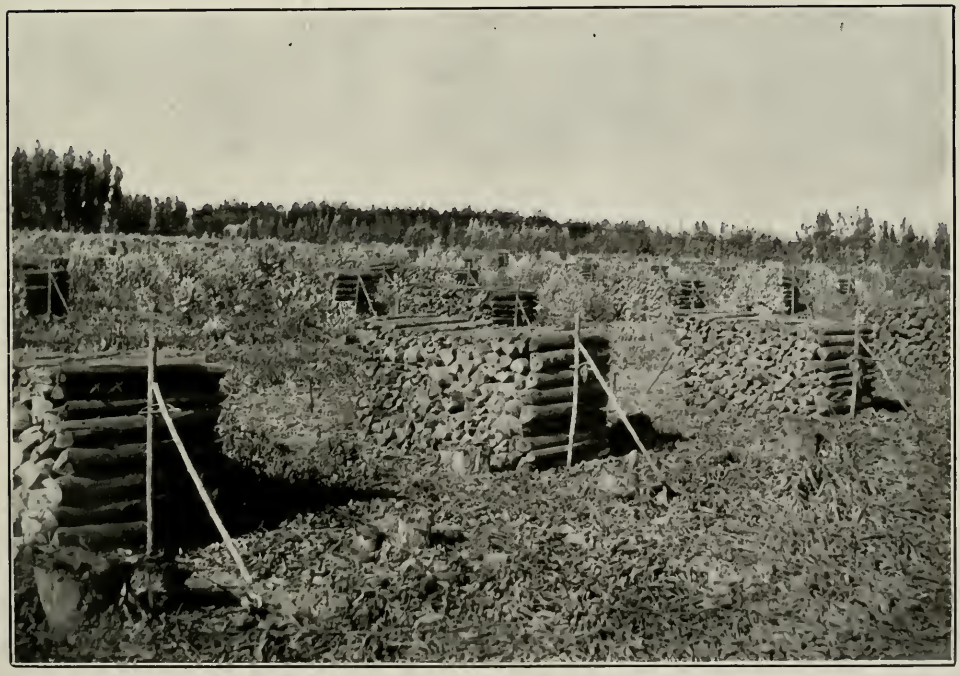
The most comprehensive work on the Eucalypts is Baron von Mueller's Eucalyptographia, a ten-part illustrated monograph, published by the government printer at Melbourne, Australia, and by Trubner & Co., London, 1879 to 1884. One hundred species are illustrated and described, with their climatic requirements and their uses quite fully given. Baron Von Mueller expressed in the final number a hope that during the years remaining to him supplemental parts might be

A. WOOD CUT FROM A BLUE GUM GROVE NEAR LOS ANGELES, CAL.

B. WOOD CUT FROM RED GUM (EUCALYPTUS ROSTRATA) GROVE UPON RANCH OF ELLWOOD COOPER NEAR SANTA BARBARA, CAL. (YOUNG GROWTH FROM STUMPS IN BACKGROUND.)

EUCALYPTS AS A SOURCE OF FUEL.

A. LOGS READY TO BE CUT BY STEAM SAWING MACHINE. VISIBLE IN BACKGROUND.



B. FOUR-FOOT WOOD RECENTLY CUT FROM GROVE OF BLUE GUM (EUCALYPTUS GLOBULUS).

The 20-acre tract averaged 80 cords per acre, the growth of seven years, from stumps of trees previously cut for fuel twice. Sprouts are appearing from some of the stumps.

A. ONE YEAR'S GROWTH.

B. THREE YEARS' GROWTH.

BLUE GUMS (EUCALYPTUS GLOBULUS) GROWING FROM STUMPS OF TREES CUT FOR FUEL.

A. EUCALYPTUS ROSTRATA AT COOPER RANCH, SANTA BARBARA, CAL.

B. EUCALYPTUS RUDIS AT MINNEWAWA RANCH, FRESNO, CAL.

EUCALYPTS GROWING SPONTANEOUSLY UNDER PARENT TREES.

issued, discussing a portion at least of the 20 to 30 species that he then recognized as remaining untreated in his Eucalyptographia. That he did not, however, expect to bring the work upon the genus to a close before his death is shown by the following: "The author can not hope during the remaining brief period of his lifetime to complete the present work with some approach to exhaustiveness of the subject." Though he continued working on the genus during much of the remaining fourteen years of his life, no additional parts were issued. The great man had devoted, with remarkable energy and enthusiasm, nearly half a century to the study of the genus, without exhausting the subject or completing a work that purported to cover it. Unfortunately the Eucalyptographia is now out of print, and it is practically impossible to secure a copy by purchase. There are probably but five copies of the work in America, with little possibility of the number ever being increased.

The fullest treatment of the genus Eucalyptus from the botanical standpoint is to be found in Volume III of the Flora Australiensis, by Bentham and von Mueller, published in 1866 by L. Reeve & Co., London. This volume contains botanical descriptions of all the species then known, 135 in number. The common colonial names of a large number of the species are given, and the part of Australia in which each species was reported as growing is stated.

Rev. William Woolls, of New South Wales, is the author of two works containing much information concerning the genus: A Contribution to the Flora of Australia; The Genus Eucalyptus, and The Plants of New South Wales. J. Ednie Brown, in New South Wales; I. G. Luehmann, in Victoria; A. W. Howitt, in Gippsland, and Walter Gill, in South Australia, have each contributed to the literature of the subject.

Mr. Joseph H. Maiden, director of the botanical gardens at Sydney, New South Wales, and Mr. F. Manson Bailey, colonial botanist, Brisbane, Queensland, are actively engaged in work upon the genus. Mr. Maiden is in a sense continuing the work of Baron von Mueller. His papers upon the Eucalypts as timber trees in Australia and upon the new species that he, in conjunction with Henry Deane, has detected, are very valuable. Maiden writes that he is at present engaged upon the manuscript of a Revisio Critica which he hopes to publish before long. Such a publication from his pen will be of incalculable value to students of the Eucalypts, and will undoubtedly do much to remove the confusion that now exists concerning the names of many species. His descriptions already published, both botanical and popular, are models of clearness, conciseness, and completeness.

The French have been prolific writers upon the culture and uses of the Eucalypts, but their articles are usually brief. Most of their publications treat especially of *Eucalyptus globulus;* some, however, are general, but only a few discuss the various species separately.

The late Charles Naudin, director of the botanical laboratory at La Villa Thuret, Antibes, was the author of two works on the Eucalypts, the first, published in 1883, entitled The Eucalyptus introduced into the Mediterranean Region;" the second published in 1891, entitled Description and Use of Eucalyptus introduced in Europe. Besides a discussion of the general characteristics of Eucalypts, they contain descriptions of the species grown about the Mediterranean, 56 in number, of which 13 were established by Naudin himself as a result of his cultural tests and his observations on the growth of Eucalypts in his region.

The most extended general treatise on Eucalypts in the French language is Les Eucalyptus, by Felix Sahut, of Montpelier. It contains a discussion of this genus, principally with reference to its geographical distribution, together with a history of its discovery; and also gives descriptions of its forest, industrial, sanitary, and medicinal adaptabilities, with suggestions regarding its culture.

Of the many other French writers on the Eucalypts, the following have treated of their culture in France: Ramel, Raveret-Watel, Planchon, Nardy, Certeux, Joly, and Combes; of their culture in Algeria, Lambert, Cordier, Bertheraud, and Trottier; in the island of Corsica, Carlotti.

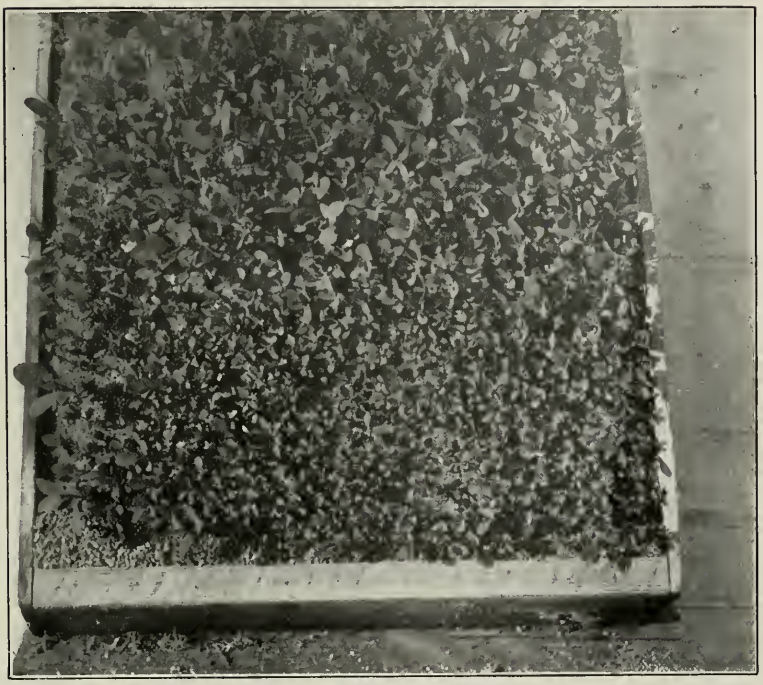
AMERICAN.

A few publications treating of the Eucalypts have appeared on the Pacific coast. The first, a compilation by Hon. Ellwood Cooper, was published in 1876. The work consisted of a popular lecture (previously mentioned) on "Forest Culture and Australian Gum Trees," by Mr. Cooper; two lectures of a similar character by Baron von Mueller; a paper by the latter upon "Australian Vegetation," and descriptions of species of Eucalypts copied from the writings of Baron von Mueller and from a seed catalogue.

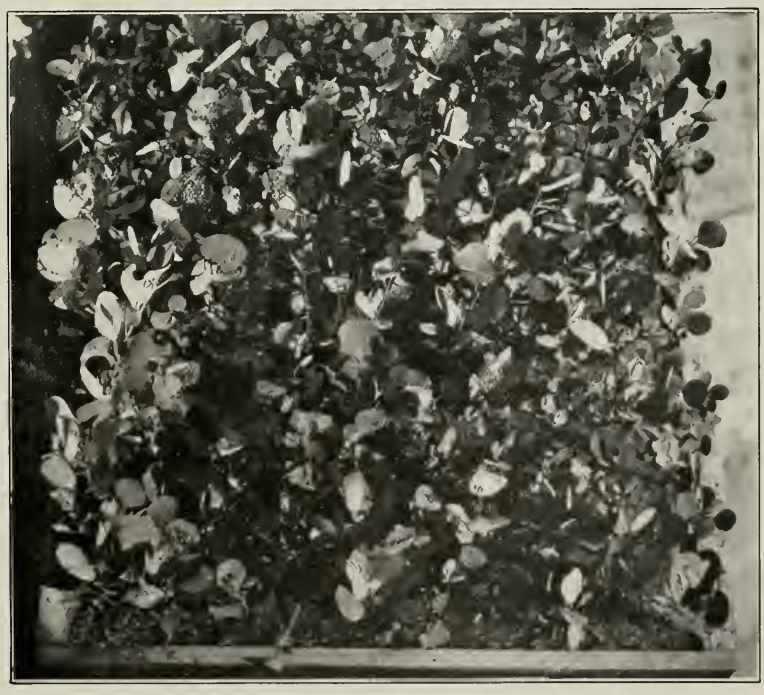
The most extensive American work on the genus appeared in 1895—an illustrated volume of 300 pages, from the pen of Hon. Abbot Kinney and the press of B. R. Baumgardt & Co., Los Angeles. This important work treats the Eucalypts from the æsthetic, the botanical, and the utilitarian standpoints. An unfortunate lack of system detracts from the usefulness of the book; but it is a mine of valuable information and suggestions. Each species that was known by Mr. Kinney to be growing in California is discussed. The work also contains directions for planting and caring for Eucalypts; the results of cultural tests of a large number of species, and the results of the distillation of the oil from 26 species; several papers by other writers upon the medicinal and chemical phases of the subject; and many useful tables and other matter from Baron von Mueller's great work. Most

of the botanical portion and many of the illustrations were contributed by the writer of this work.

Mr. J. Burtt Davy, of the University of California, contributes the article upon "Eucalyptus" in Volume II of Prof. L. H. Bailey's Cyclopedia of American Horticulture. The article contains brief botanical descriptions of 52 species, summarized from Baron von Mueller's Eucalyptographia, and "verified by reference to herbarium specimens wherever these were available." Some statements in this article concerning the propagation of Eucalypts do not agree with experience here in the Southwest, where the growing of seedlings is not a simple matter.



A. READY TO TRANSFER TO FRESH SOIL.

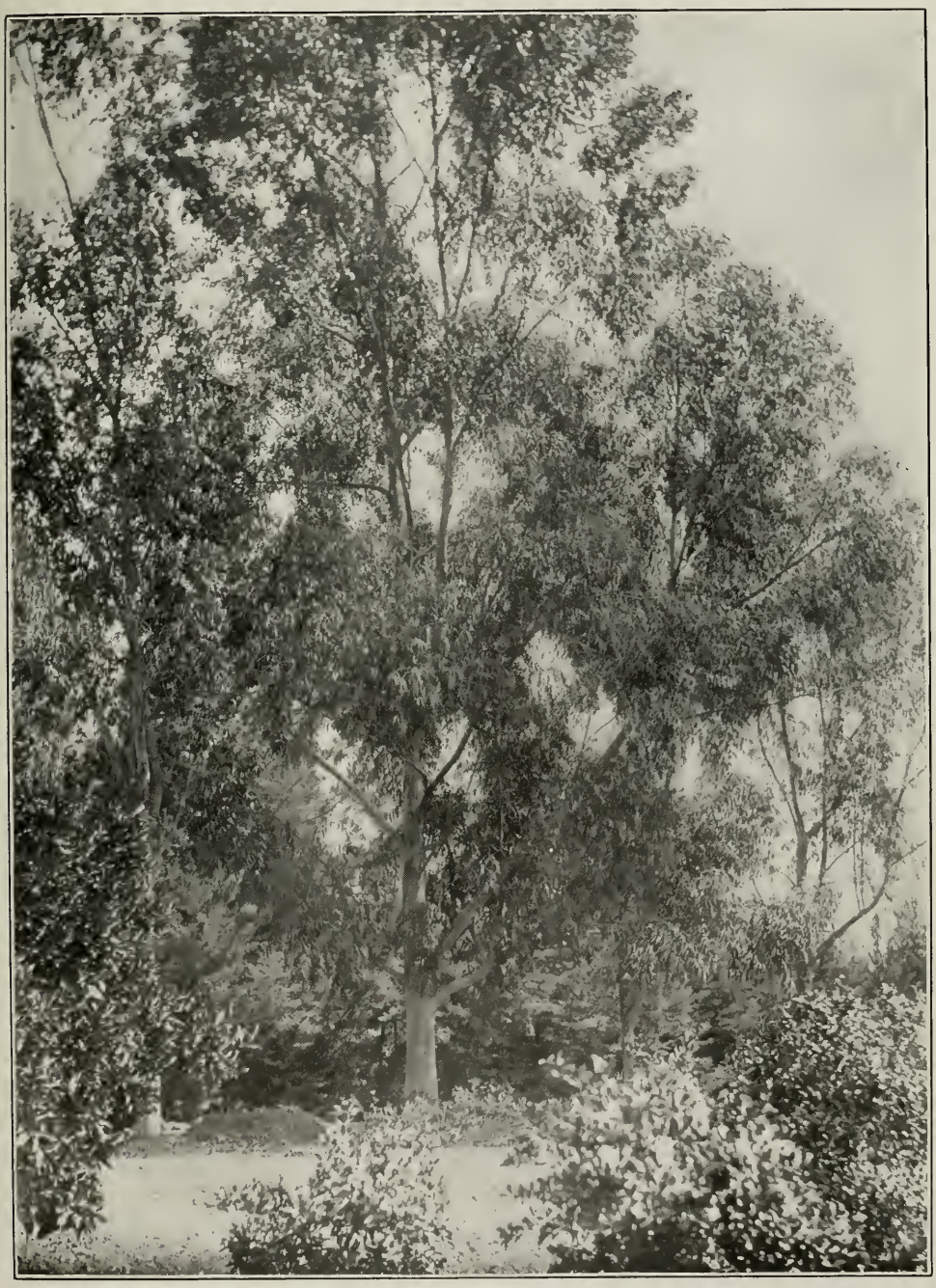


B. READY TO SET IN FIELD.

EUCALYPT SEEDLINGS IN PROPAGATION BOXES.

EUCALYPTUS AMYGDALINA, EAST LAKE PARK, LOS ANGELES, CAL.

EUCALYPTUS BOTRYOIDES. TREES 3 YEARS OLD.



EUCALYPTUS BOTRYOIDES. TREE 15 YEARS OLD.

PART II.

CHARACTERISTICS OF THE GENUS EUCALYPTUS.

GENERAL CHARACTERISTICS.

The genus Eucalyptus includes about 150 species. Most of them are trees of large size; some of them among the largest in the world. They range, however, from immense trees towering high on plains and hillsides down to small shrubs that cover desert or alpine regions.

They grow in a great variety of soils and climates, the various native environments having thus resulted in the development of species that are quite different from one another. In their native home they grow both scattered and in forests.

The Eucalypts are all evergreens, a fact that should be taken into consideration when planting them.

Many of the species are vigorous growers, a few being especially noted for the great rapidity of their growth. The Blue Gum (*Eucalyptus globulus*) is one of the fastest growing of the genus. On the ranch of Hon. Ellwood Cooper, near Santa Barbara, Cal., trees of this species 25 years old are as large as oaks whose rings show them to be 200 to 300 years old. As to their growth in France, Prof. Charles Naudin, in his memoir on Eucalyptus, published in 1891, says:

> In a score of years they (the Blue Gums) attain at least the volume and the height of an oak a century old. Some others, though not growing as rapidly, are moreover remarkable for the short time in which they may be used for carpentry, for joinery, for carriage making, for agricultural implements, for railroad sleepers, and for telegraph poles.

It is this rapidity of growth, enabling them to reach the stature of trees in a few years, that has been the principal cause of the popularity of the Eucalypts where they have been introduced.

Most species if pruned, or if cut off at the ground, sprout freely, sending up shoots that usually make a very vigorous growth. This makes it possible to cut the trees for fuel, for timber, or for other purposes, and in a comparatively short time to again have a forest containing as much timber as before the trees were cut. A Blue Gum (*Eucalyptus globulus*) 8 to 10 years old, if cut to the ground, will send

up shoots that will reach a height of 75 or 100 feet in from six to eight years. Several other species make an almost equally rapid growth after being cut. The cutting may be repeated every few years for an indefinite period.

Eucalypts are propagated only from seed. To this fact is due their comparative freedom from injurious insects and from diseases usual to exotics which have been introduced into America by cuttings or seedlings. Their dissemination throughout the world having been by seeds alone, the insect enemies and the parasitic fungi of their native home have been left behind. In America they have few insect enemies, and they are remarkably free from disease.

THE TRUNK.

The character of the trunk varies considerably. Of many species the trunk is erect and straight-grained; of others it is more or less curved and twisted. In the majority of species the trunk diminishes in size upward very gradually, being long and cylindrical. It is this characteristic that makes many of them so admirably adapted for masts, piles, bridge timbers, and telegraph poles.

The bark of the different species shows great variety. In some it is very rough, while in others it is quite smooth. In many species its character changes considerably with age. The bark of all seedlings is smooth, that of some remaining so permanently, that of others becoming more or less rough and furrowed as the tree grows older. Some rough barks are fibrous and stringy on the outside, while others are hard and brittle. Trees having the former kind of bark are commonly known as stringy-barks; those having the latter, as iron-barks. Intermediate between the above two types is a bark, somewhat fibrous, but more or less scaly on the outside, like that of the American Ash. Of several species the bark of the limbs is much smoother than that of the trunk; and often, in the same species, the surface of the bark varies considerably, being modified by the soil and climate. The bark remains permanently on the trunks and limbs of some species, while from others the outer layer falls away freely in sheets or strips, leaving the fresh surface smooth and lighter in color. The surface of the bark of different species varies in color from light cream to dark brown.

The matured wood of all species is hard—of some species very hard. Of many species it is tough and durable, resembling in this respect the wood of American oaks and hickories. The wood of some species is heavier than water. The wood varies a good deal in grain, being straight-grained and easily split in some species, while in others it is gnarled and splits with great difficulty. For this reason the various species furnish timber adapted to a great variety of uses. The color of the wood varies from clear white to a rich brown.

THE FOLIAGE.

The Eucalypts present great variety in the appearance of their foliage. Of some species it is bluish, of others a light or grayish green, and of still others a very dark green. Of some the foliage is dense, but of many species it is open, affording but little shade. The foliage and young twigs of all species possess a more or less pronounced odor, due to the presence of oil-dots. To the majority of people the odor of most species is agreeable—in some cases quite fragrant.

Of many species the leaves of the young seedlings are of a different shape from those of the adult tree. As a rule, the leaves of the seedling tree are broader, shorter, and shorter-stemmed than those of the older ones. As the tree grows older, the newly formed leaves are commonly successively longer and narrower, until the adult form is reached. This change usually occurs during the first year or two of the tree's growth. The leaves of some species are opposite on the stem of the young seedlings, becoming scattered as the change to the adult leaf-form occurs. Only a few species have permanently opposite leaves. These marked characteristics in seedling leaves furnish one means of identifying species. A grower or purchaser of young Eucalypts, if he knows what the nature of the leaves should be, can distinguish the species very early in their development. It is for the purpose of furnishing assistance on this point that the illustrations of seedlings are given in this publication. (See Pls. LXXXI to LXXXIX.)

The mature leaves of most species are comparatively long and slender, the prevailing shape being that of a lance, or somewhat curved like a sickle. They vary considerably as to texture, those of some species being thin and papery, while those of the majority are more or less thick and leathery. Instead of spreading horizontally and being darker colored above than below, as is the case with most flat-leafed trees, the leaves of the majority of species present one edge to the sky, the two surfaces consequently having the same or nearly the same appearance. Those species with leaves spreading horizontally naturally furnish more shade than those whose leaves hang with one edge skyward.

THE BLOOM.

The Eucalypts bear flowers that are more or less conspicuous. The flowers of different species differ sufficiently to render very material help in deciding upon the correct name of a tree. The greatest differences are in the flower buds, which, just before they open, are much more useful in determining the species to which a tree belongs than the open flowers. Most species bloom freely and many bloom very profusely. The trees of most species produce flowers early in their development, blossoms sometimes appearing on 2 or 3 year old

trees that attain, when full grown, a height of 100 to 300 feet. This early blooming greatly facilitates their identification and their propagation from seed. The flowering periods of the different species vary considerably, extending through the entire year. Some species remain in blossom a large portion of the year, some bloom during two distinct periods of the year, while of others the flowering season is quite limited.

The flowers usually grow in clusters, which botanists call umbels, rarely singly. The clusters are borne at the leaf axils or at the ends of branches, usually singly; but in some species several clusters are found arranged in what botanists call a panicle. The unopened flower buds are hermetically sealed by a close covering that corresponds to the outer leaves, or calyx, of most other flowers. It was this close covering of the flowers that suggested to L'Hertier, the botanist who discovered and named the genus, the name Eucalyptus, the word meaning in Greek "well concealed." As the flower opens, the upper part separates as a lid and falls away, while the lower half of the calyx remains permanently and incloses the developing seeds. At the same time there falls away a less conspicuous under covering that is thought to correspond to the petals of other flowers. The flowers when open, therefore, are destitute of any enveloping flower leaves. The stamens constitute the most conspicuous feature of the opened flowers, being usually very numerous. They differ considerably in color, the prevailing tint, however, being greenish or yellowish white. Of some species the stamens are highly colored, thus causing the flowers to be strikingly beautiful, and consequently highly prized for ornament.

THE SEEDS.

The persisting portion of the calyx becomes a firm, tough covering for the seed case, which endures much weathering and usually remains on the tree for a considerable period. The seed cases of the different species vary in size from one-eighth of an inch to 1 inch in diameter. The shapes are various, the prevailing forms being that of a cup, a goblet, a top, or an egg. As the seed cases mature the upper covering separates into from three to five tooth-like bodies termed valves, and the seeds fall out between them. The valves when open either project from the mouth of the seed case or are included in it. The shape of the seed case and the position of the valves peculiar to each species furnish valuable data for determining the name of a Eucalypt.

The seeds are, with a few exceptions, quite small and very numerous, many, however, usually being infertile. The smallness of the seeds (the usual length being 0.04 to 0.1 inch) makes their transportation easy and the rearing of young plants on a large scale practicable. The number of young plants that the seeds of a single tree would produce per year is enormous.

EUCALYPTUS CALOPHYLLA, EAST LAKE PARK, LOS ANGELES, CAL.

EUCALYPTUS CITRIODORA—TALL FORM. TREE 15 YEARS OLD, COOPER RANCH, NEAR SANTA BARBARA, CAL.

EUCALYPTUS CITRIODORA—SPREADING FORM. TREES 20 YEARS OLD, COOPER RANCH, NEAR SANTA BARBARA, CAL.

EUCALYPTUS CORYMBOSA, STATE FORESTRY STATION, SANTA MONICA, CAL.

RELATION OF THE EUCALYPTS TO CLIMATE.

GENERAL CLIMATIC REQUIREMENTS.

The Eucalypts differ considerably as to the climatic conditions under which they thrive, but all the larger arboreal forms agree in requiring a warm climate. Not only do they prefer a climate that is equable, but other conditions must exist in order that they may be grown successfully. Prof. Charles Naudin, in his memoir on the genus, gives quite concisely the conditions required for the successful growth of Eucalypts. He says:

> The first condition of success in the culture of Eucalyptus is a climate appropriate to their nature; that is to say, for a great majority of the species, warm summers, a moderate amount of rain, a certain atmospheric dryness, plenty of sunlight, and very temperate winters.

While all thrive best in regions with warm summers, many species do not endure the summer heat of certain sections of southwestern North America. Regions where the midsummer maximum temperatures range from 80° to 105° F. are best suited to the growth of these trees. Some species thrive in regions where the maximum temperatures range in summer from 100° to 120° F., but the number is limited. The various species differ very much as to the amount of cold they will endure. Some will stand minimum temperatures of 10° to 15° F., while other species will under no circumstances endure temperatures much below freezing. The degree of cold that any species will endure depends not only upon the other conditions of the atmosphere at the time, but upon the nature of the weather that has preceded. Low temperatures following a warm period that has stimulated growth do much more injury than the same degree of cold following a gradual fall in temperature.

While most Eucalypts are benefited by occasional heavy rainfalls that saturate the soil thoroughly, frequent rains and a very humid atmosphere are not conducive to their healthful growth. They have the power of absorbing great quantities of water by means of their roots, but the above-ground parts of most species prefer to be in quite dry atmosphere, at least for a portion of the year. A few species grow in swampy, humid regions, but the majority of them prefer drier situations. Plenty of sunlight is quite essential to the healthy growth of most species, few of them thriving in the shade of other trees or in regions having much cloudy weather.

CLIMATIC AREAS IN NORTH AMERICA.

With regard to the effect of climate upon the Eucalypts, we may divide the United States into four sections. In the first and largest division the winters are ordinarily so cold as to kill the Eucalypts, and their growth there outdoors is consequently impracticable. This

region comprises all of the United States except a strip varying from 100 to 300 miles in breadth along the southern and the southwestern border.

In the second division the winters in most years are so mild that growth is not checked; but during some winters a cold wave passes over the region that kills the whole, or a large part of the tree that has grown during the years in which no unusually cold period occurred. In this section Eucalypts never, or rarely, become dormant; and when a cold wave comes they are unprepared for it, the result being disastrous. This region consists of Florida and the adjacent coast region of the south Atlantic and the Gulf of Mexico. In Florida the conditions seem to be especially trying. Col. G. H. Norton, of Eustis, Fla., writes, under date of February 6, 1900:

> All Eucalypts do well, but are killed to the ground when a very severe blizzard comes and the mercury falls much below 20° F. The trouble with the climate is, we have warm weather nearly all the time in winter, with an occasional cold wave.

Possibly there may be a species as yet untried there that would withstand the conditions described.

In the third division the minimum temperatures, while commonly quite low during midwinter, decrease so gradually during the latter part of autumn that the growth of the previous year has time to mature. It is thus able to endure a low temperature that would be fatal in the second division, discussed above, where the weather is alternately warm and cold. In other words, these evergreens, in common with the others of the region, both native and exotic, become dormant, just as native evergreens do in the colder first division. For this reason many Eucalypts can be grown there that can not be successfully grown in the second division, even though the mean temperatures of the winter may be higher in the latter. This region consists of the interior valleys of part of Texas, of southern New Mexico, of southern Arizona, and of southern California. In much of this region the summers are so dry and hot that many Eucalypts can not endure them. Consequently, the species that thrive in this section are those that both endure a very dry, hot atmosphere and become sufficiently dormant during the winter to endure the low temperatures that occur. The species of which this is known to be true are *Eucalyptus rostrata*, *E. rudis*, *E. leucoxylon*, *E. hemiphloia*, *E. polyanthema*, *E. melliodora*, *E. corynocalyx*, *E. tereticornis*, and *E. salubris*.

In the fourth division the climate is so equable that nearly all species of the genus Eucalyptus will grow in it. In this region the mercury rarely falls below 25° F. during winter nor rises much above 105° F. during summer, and the atmosphere is commonly moderately humid. This division consists of the coast region of central and southern California. It is the section of the United States in which Eucalypts are grown most extensively and most successfully.

Mexico might be similarly divided into four Eucalypt areas. The territory of these divisions would not necessarily be contiguous, but would be determined by elevation rather than by latitude or longitude.

USES OF EUCALYPTS.

The Eucalypts probably serve more useful purposes than the trees of any other genus grown on the globe, except, possibly, the various palms. Their uses are very diverse. As they grow they serve as a forest cover to mountains, hills, plains, and swamps, as wind-breaks, and as shade trees. While growing they are also the source of many gums and resins, and of honey. When cut, they furnish valuable timber, excellent fuel, and a very useful oil. Besides all this, many of them are ornamental, and they have the reputation of improving the climate of the region in which they grow. Being hardwood trees, they serve the useful purposes that hardwood trees ordinarily serve, and besides furnish many useful products similar to those obtained from a variety of other trees, and from shrubs and herbs. This great variety of uses is made available, in regions where they have but recently been introduced, by reason of their very rapid growth, it being possible to enjoy many of their uses while the trees are still standing, and to obtain from them many useful products within a very few years after planting them.

AS A FOREST COVER.

It is as forest trees that the Eucalypts are most useful; planted as ornamental or as shade trees they are often disappointing. Planters who have put them out as forest trees are the ones who have derived the greatest benefit from them. (Pl. I, A.) Hon. Ellwood Cooper, of Santa Barbara, was one of the first Americans to recognize the prospective value of Eucalypts as forest trees. He acted upon his conviction, and has for a score of years been reaping the reward. Besides enjoying the beauty and shade of his groves, as well as the beneficial changes they have wrought in the climate of the region, he has for many years received from them an annual income of no inconsiderable amount. Those who have planted them singly or in small groups as ornamental or shade trees have received little or no financial return, and have in some cases been disappointed in them because not serving, as they had hoped, the purpose for which they were set.

In many of the semitropic portions of the globe the Eucalypts are the trees most suitable to plant for forest cover. Much of the treeless land of semitropic America might be covered with these trees. As the conditions under which the different Eucalypts grow in Australia are very diverse, it is evident that, if the species are properly selected, they will cover nearly all kinds of situations.

The species suited to particular localities or conditions may be ascertained by reference to pages that follow. Those that grow in Australia on the uplands and in other dry situations can be used here to cover similar regions. In the Southwest there are large areas of hilly country, of little or no use for other purposes, that might be transformed into useful forests by covering them with these trees. This covering of the hills with forests will not only furnish shade, a source of honey, and a supply of fuel and timber, but will prevent the too rapid run-off of rain water, which results in the cutting and washing of hillsides and in other forms of damage below. On this point Mr. Cooper, in a letter to the writer dated June 18, 1900, says:

> South of where I live, about one-eighth of a mile, is a steep hillside. I noticed during my residence the first years that heavy rains washed down the soil, all the rain running off. I planted Eucalyptus trees on this hillside, about 4 feet apart. When these trees had four or five years of growth we had a tremendous rain storm, 14 inches of rain falling in four days. Nearly all this water was held by the trees, practically none running off. There is always more moisture in the soil near these trees than some distance off. There is no question as to the great importance of having our mountain sides well wooded with trees and bushes to preserve the rain for the benefit of the valley below.

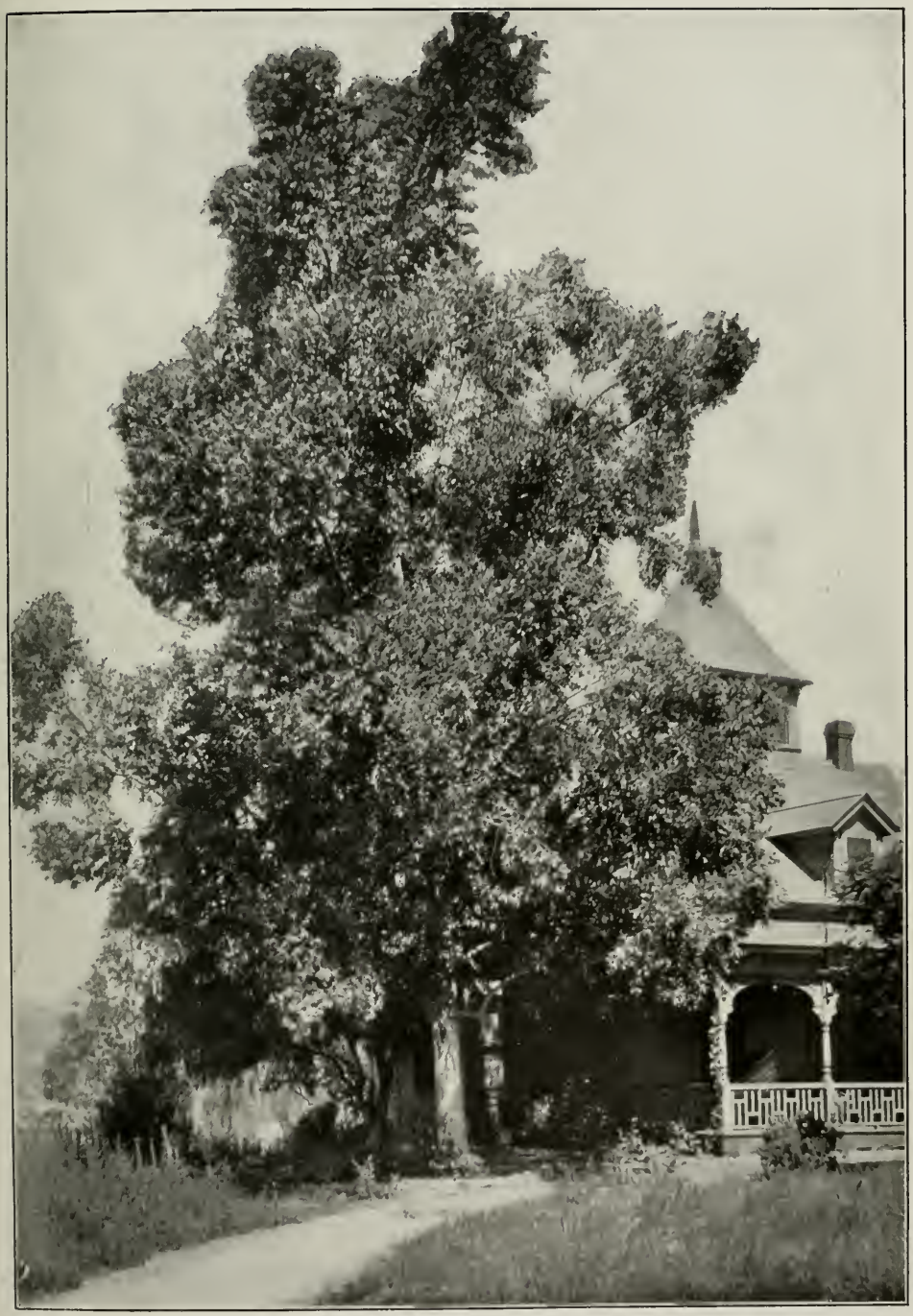
The Eucalypts can be utilized as a forest cover for mountains as well as hillsides. Several species grow naturally upon the mountains of Australia. These will serve as a covering for bare mountain sides in the Southwest, and the writer believes that they would prove quite valuable for recovering those that have been denuded of their natural forests by fire. The rapid growing species, less resistant to frost, could be planted on the lower parts of mountains, and the somewhat slower-growing, more hardy ones farther up the mountain sides. Those adapted to alpine situations may be planted to a height of from 4,000 to 6,000 feet.

Lowlands, too, may be covered with Eucalypts. In Australia several species grow naturally in swamps or other low situations. These may be utilized for covering the lowlands in warm regions in other parts of the world, thus reducing the amount of the stagnant water, and in other ways rendering such localities more agreeable.

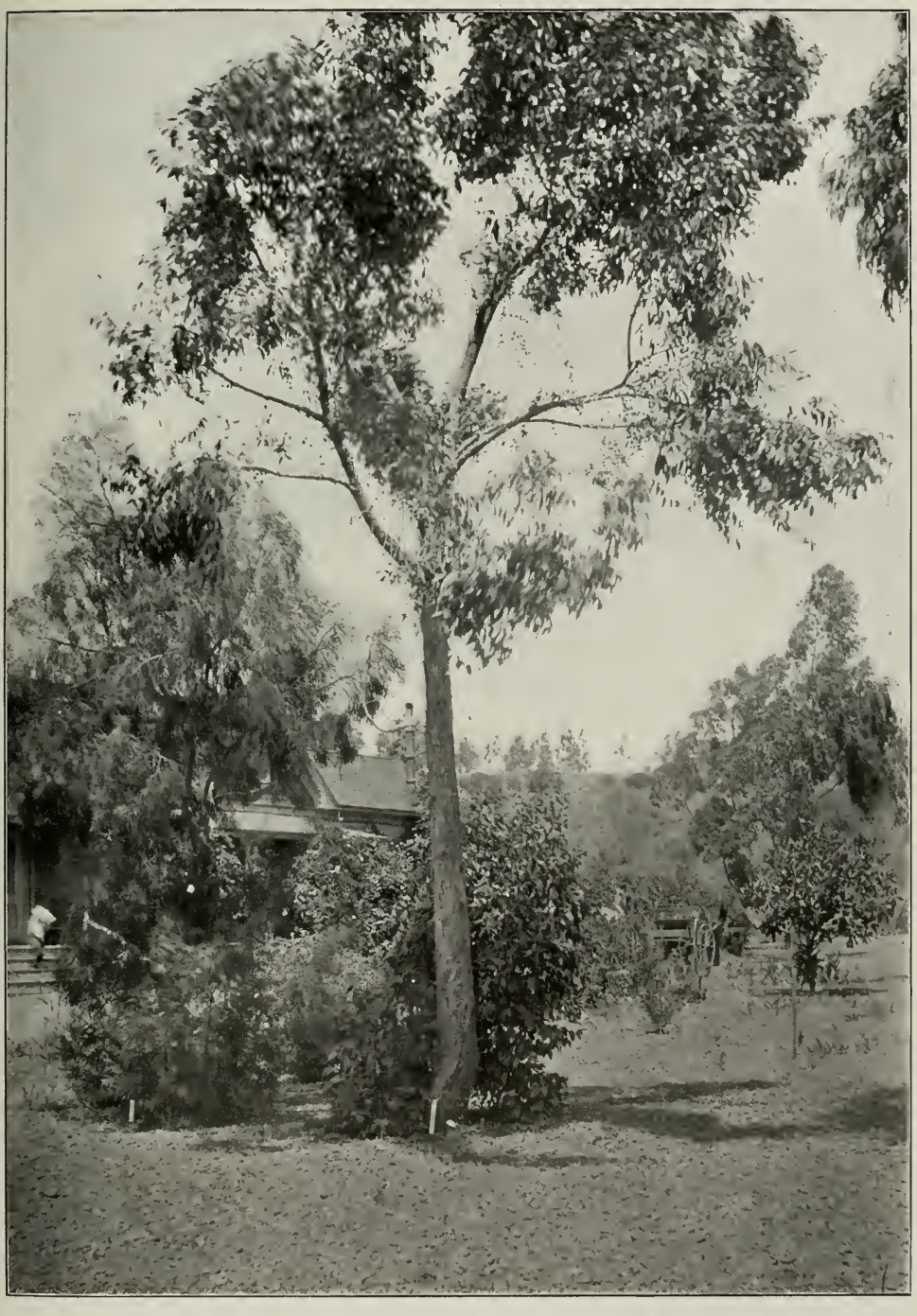
Judging from observations made during the past few years (the most trying years upon vegetation that have been experienced in the Southwest since it was settled), the writer believes that much of the treeless desert region might be forested with Eucalypts. At the close of the season of 1900, the driest one of which the Weather Bureau has a record, trees of several species were observed growing without irrigation in southern Arizona, and some of them had not been irrigated for many years. Trees of the Red Gum (*Eucalyptus rostrata*), the Sugar Gum (*E. corynocalyx*), and of *E. tereticornis*, growing in a neglected tract under desert conditions where the ground water was about 100 feet below the surface, endured the above trying summer. This

EUCALYPTUS CORYNOCALIX, SHOWING TRUNKS SUITABLE FOR FENCE POSTS.

EUCALYPTUS CREBRA, COURT-HOUSE GROUNDS, FRESNO, CAL.



EUCALYPTUS DIVERSICOLOR, NEAR SOUTH PASADENA, CAL.



EUCALYPTUS EUGENIOIDES, STATE FORESTRY STATION, SANTA MONICA, CAL.

indicates that these, and probably other species, might be used as a forest cover for similar desert regions. In order to get the seedlings started it would be necessary to water and cultivate them a year or two, after which they would be supported by the rainfall, especially in localities where the ground water is near the surface.

AS WIND-BREAKS.

In the Southwest the Eucalypts have been found very useful as wind-breaks. Their quick growth and varied habit make them peculiarly adaptable for this purpose. Thus a low tree with dense foliage may be selected where a low, close wind-break is desired, and a taller species where a higher and less dense shelter is needed. Owners of orchards, especially citrus orchards, have found them particularly beneficial as a break to the strong winds and a protection during cold weather. (Pl. I, B.)

On this point Mr. Nathan W. Blanchard, of Santa Paula, one of the most extensive growers of citrus fruits in California, in a letter dated June 11, 1900, makes the following statement:

> In reference to Blue Gum wind-breaks, I prefer them to any other. They grow rapidly and break the force of the wind, which is what is required. A solid wind-break like a Monterey Cypress, the wind sometimes falls over and has a twisting effect on the trees, similar to wind coming from a high mountain range. With my experience in this valley I would plant the wind-breaks about 450 feet apart.
>
> The Limoneira orchards are laid off in sections, putting the Blue Gums 40 rods apart, but I think this distance is too great and it is too far to run the water economically. My wind-breaks are about 450 feet apart, and are so effective that one does not feel the wind at all among the orange trees. Neither is my fruit in the least impaired by the wind, however strong it may blow down or up the valley. My orchard ditches are along the wind-breaks, and the trees therefore get all the water that they need and do not draw upon the moisture of the orchard to the detriment of the fruit trees. Indeed, I have some orange trees alive that are growing right under the Blue Gums, bearing some good fruit. If the Blue Gums are sufficiently supplied with water they have no injurious effect upon the trees other than the shade, and on the east side of the wind-breaks my trees are more thrifty, or at least bear more fruit, than the average, while on the west side the shade is somewhat detrimental to the amount of fruit that I secure.

Upon the above subject Mr. Ellwood Cooper, of Santa Barbara, in the letter previously mentioned, writes as follows:

> The fruit orchards where protected have larger growth and cleaner leaves and stems. Less fruit blows off during high winds. I know of an orange orchard at Santa Paula where Eucalyptus trees were planted on the east and west sides—quite a distance between. The trees on either side, where protected, were twice as large as those in the center; in fact the orchard was sloping from the protected sides to the center. The center rows were taken out and Eucalyptus trees planted. The orchard now shows a uniform appearance.

Mr. Cooper also speaks of the value of the Eucalypts as a wind-break for grain fields. On this point he says:

> In wheat and barley farming I found that in the immediate vicinity of the groves

of Eucalypti there was a much heavier crop and taller straw. Near the ocean, where the trees protected the grain from sharp sea wind, there was certainly more than twice as much grain and twice as much straw. The unprotected grain had over one-third to one-half the heads blasted—no grains in the injured parts. The straw had a rusty appearance. From facts actually established I have made the statement that three-fourths of an area will produce more grain or fruit with the other fourth in forest trees than four-fourths without the forest trees; hence the great economy in tree planting.

The last statement would not apply to all regions, but of those swept by heavy winds it is undoubtedly true. There are large areas in Ventura County, Cal., that would not be tillable but for the Eucalypts. Part of the land is so sandy that formerly it was blown about by the wind, and not only the crops growing in it, but those of adjoining fields were seriously damaged. The planting of Eucalypt wind-breaks has so moderated the wind velocity that now little damage is ever done by it.

Many fruit growers in southern California believe that wind-breaks of Eucalypt trees protect their orange and lemon orchards from frosts. The question was a subject of discussion at a large horticultural meeting held in that section April 29, 1901. In the Los Angeles Times's report of the meeting is the following:

Four hundred people, representing ten farmers' clubs, met Monday at the ranch of George Turner, near Cucamonga, to study the system of wind-breaks established there as a protection against frosts. The visitors were seated among the Eucalyptus trees which they had come to study. "Frosts in relation to wind-breaks" was the subject of a paper by John Hoffman, of Cucamonga. In stating the results of his investigations he said "the temperature is usually higher on the north side of a wind-break than on the south side," and that, since his orchard had grown large, "the ground had frozen but once, and that was at a distance from the wind-break."

AS SHADE TREES.

While many of the Eucalypts are not especially desirable shade trees, the fact that they will grow well in many situations where other trees make poor growth, or will scarcely grow at all, gives them considerable value for this purpose. They are especially suitable for country roads, for the vicinity of barns and other farm buildings, and for shade in pastures. As road shade trees, many species have proved very useful in the Southwest and have been much used for this purpose. (Pl. II, A, B.) Mr. Cooper, in the letter already mentioned, writes upon this point as follows:

The public highway through my ranch, seven-eighths of a mile in length, has a double row of trees on either side. There is less mud in winter and less dust in summer than on the road at either approach.

The writer observed the latter fact while there during August. In regions where there is less sunshine and more rainfall than there is at Santa Barbara it might be well to plant the trees farther apart on the sunnier side of the road to permit the road to dry after rains. In many

cases the trees can be so set along the road as to serve both as a windbreak against the most disagreeable winds of the region and as shade trees during summer. (Pl. III.) In all cases the fact that these trees are evergreen, and consequently shade-producing both winter and summer, must be taken into consideration. In regions where heavy winter rains occur it would not be wise to plant Eucalypts so thickly as to keep the road from drying.

In many parts of the Southwest the Eucalypts are utilized to advantage to furnish shade in pastures. If set along the fences and along irrigating ditches they can be made to protect the animals in the pasture without at any time interfering with farming operations. In the place of the Cottonwood and other deciduous trees, some Eucalypts would be an improvement, both in appearance and in usefulness. Even during the winter, when deciduous trees are leafless, there are many days when animals in the pasture need shelter from the sun, and many more when protection against wind and rain is needed. The Eucalypts would furnish this protection to animals. In addition they would be a source of better fuel and timber than most deciduous trees, and would add much to the appearance of the winter landscape.

AS A SOURCE OF TIMBER.

For Australia and the neighboring islands the Eucalypts are one of the important sources of the general timber supply, and are the chief source of the hard-wood timber used there. The uses made of Eucalyptus timber are remarkably diverse. It enters into the construction of buildings, ships, bridges, railroads, piers, telegraph lines, fences, paving, vehicles, agricultural implements, furniture, barrels, and a great variety of minor articles. In his Notes on the Commercial Timbers of New South Wales Mr. Maiden names twenty-five "special purposes" for which the timber of Eucalypts is used in that colony. Six species are named as valuable for bridge timbers, five as valuable for piles, nine for paving, eight for posts, three for railroad ties, four for railway coaches, five for lumber and shingles, seven for the various parts of vehicles, two for barrels and casks, and two for broom and tool handles. Eleven "special purposes" are assigned to the timber of the Spotted Gum (*Eucalyptus maculata*), ten to the timber of the Ironbark (*E. sideroxylon*), eight to that of Red Mahogany (*E. resinifera*) and Tallow Wood (*E. microcorys*), six to that of Gray Gum (*E. propinqua*), five to that of Red Gum (*E. rostrata*), and a lesser number to that of seven other species. Not only in Australia is the timber of Eucalypts used thus extensively, but it is exported in large quantities, the bulk of the hard-wood lumber shipped being from these trees. R. Dalyrimple-Hay, in his work entitled The Timber Trade of New South Wales, names thirteen species that furnish timber for export. He gives the annual output of lumber from the 108

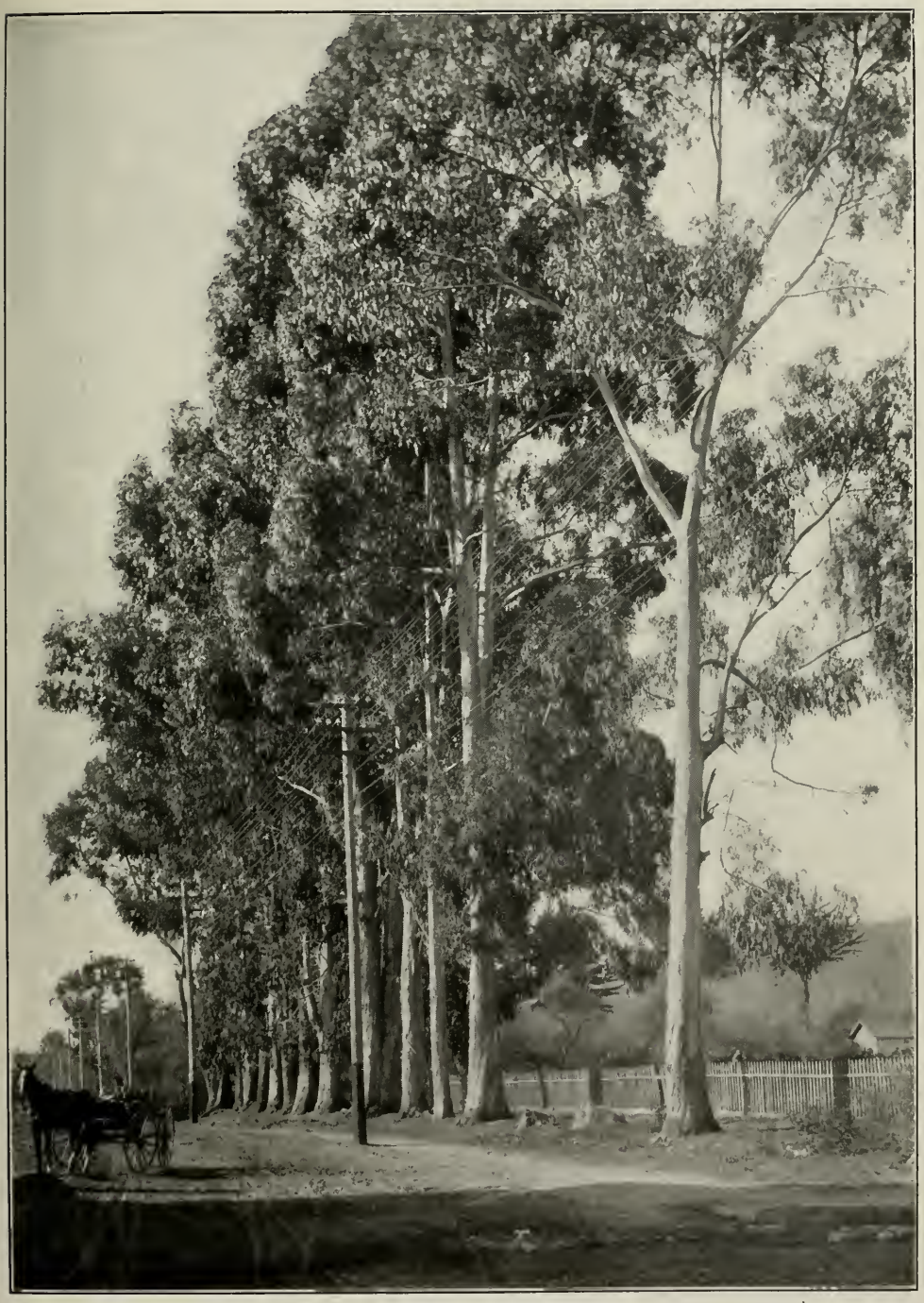
mills of the colony as 59,500,000 superficial feet, a large part of which is from Eucalypt trees. Shipments are made to distant parts of the globe, including Africa and even England.

The timber of different species of Eucalypts differs very much in character. While that of all species is hard wood, the degree of hardness, the strength, durability, flexibility, color, and many other qualities are quite different. Great differences exist also in the timber of the same species grown in different soils and climates. To these variations is due, largely, the great variety of uses that the timber of these trees serves.

In America the Eucalypts have not yet been grown long enough nor extensively enough to have become a source of lumber. The principal uses made of the timber thus far are for fuel, piles, posts, and some of the parts of farming implements, and for pins for insulators on long-distance transmission cables. The species used most for piles in southern Australia does not thrive in the Southwest, but the Blue Gum has been found to be a very durable substitute. (Pl. IV, A.) The life of Redwood (*Sequoia sempervirens*) and of Oregon Pine (*Pseudotsuga taxifolia*) piles is from four to seven years on the Pacific coast. Blue Gum piles last twice as long. The piers at Santa Barbara and at neighboring sea towns are maintained with piles of this Eucalypt. Mr. Cooper informs the writer that he has sold from his groves nearly $10,000 worth of piles during the past ten years. At Oceanside the superior value of Eucalypt piles is reported to have been demonstrated through the surreptitious acts of a contractor. Lacking a few piles of the timber specified in the contract (Oregon Pine), he is said to have obtained some Blue Gum timbers from the vicinity and to have ordered the night crew to place them on the inside, where their presence would not be detected. When it became necessary to repair the pier a few years ago some sound piles were found among others nearly destroyed, and upon examination they proved to be the Blue Gum trees. The demand for these piles is now greater than the existing groves of Eucalypts can supply. It seems probable that piles may become one of the important crops grown by farmers of the Southwest. As the trees now planted become larger, and as planting becomes more extensive, the Eucalypts will undoubtedly become sources of much timber for a great variety of purposes. (Pl. IV, B.)

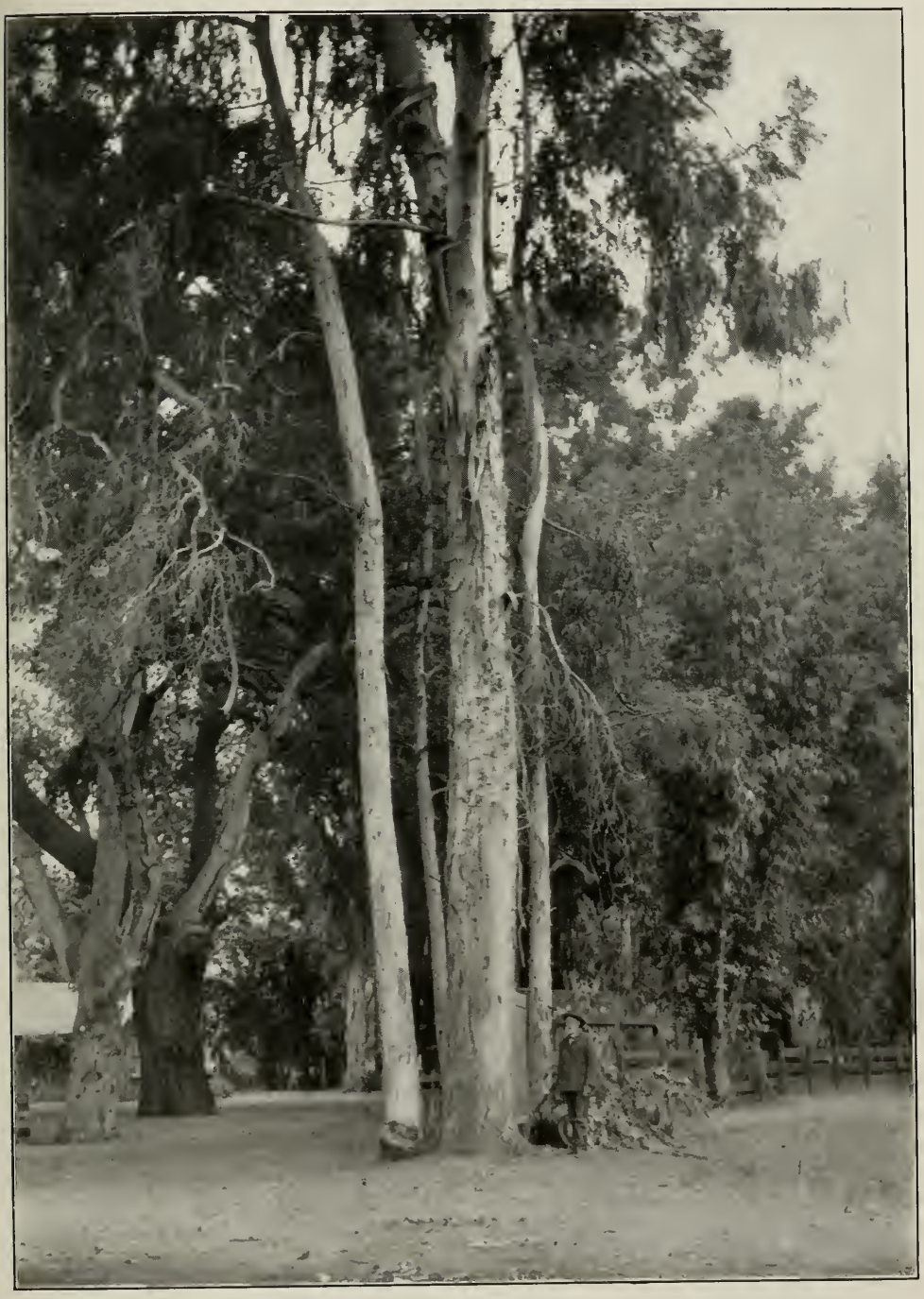
AS A SOURCE OF FUEL.

In Australia the Eucalypts are an important source of fuel. There the inhabitants find the tree, ready grown for use, and it matters little to them how long they have taken to reach their present size. Hence many species are used for this purpose. In America and other countries where the Eucalypts are grown as exotics the case is quite different. Only a quick-growing species will yield an early supply of fuel, and



EUCALYPTUS GLOBULUS, SANTA BARBARA, CAL.

A row of trees 31 years old, ranging in diameter from 3 to over 5 feet. They were among the first planted in southern California.



EUCALYPTUS GLOBULUS ON RANCH OF ELLWOOD COOPER, SANTA BARBARA, CAL.

Trees 24 years old. The largest Eucalypt has attained in twenty-four years the diameter that the oaks have in over two hundred years.

EUCALYPTUS GLOBULUS. TIMBER CUT FROM TREES IN THE BACKGROUND BEING USED TO BUILD FENCE.

EUCALYPTUS GOMPHOCEPHALA. GROVE 24 YEARS OLD ON THE COOPER RANCH.

hence the Blue Gum among the Eucalypts has been most used for this purpose. (Pl. V, A.)

The Manna Gum (*Eucalyptus viminalis*), the species approaching the Blue Gum most closely in rapidity of growth, has also been cut considerably for fuel. Other species making a slower growth produce a harder wood and better fuel. For some years Mr. Cooper has been cutting stove wood for the Santa Barbara market from his Red Gum (*E. rostrata*) and Red Ironbark (*E. sideroxylon*) groves, and finds the fuel from them superior to that from the Blue Gum. (Pl. V, B.) When other species become more generally known, or when plantings now made have reached a sufficient age, undoubtedly several species will be found better adapted for fuel than the now much-used Blue Gum. But at present that is the fuel tree of much of the State of California. (Pl. VI, A.)

When set for fuel the young trees are commonly planted either 8 by 8 or 6 by 10 feet apart. Rows 10 feet apart with trees 6 feet apart in the rows give a few more trees to the acre, and leave more space between the rows for driving with a wagon. Formerly some growers planted closer—either 4 by 4 or 4 by 8 feet—and cut out the trees as they increased in size, until they were left the distance apart they desired them to be permanently. But so much difficulty was experienced in preventing the growth of the trees desired to be eliminated that the practice has been almost entirely abandoned. The young trees are commonly cultivated for about two years after being set out.

In California some of the best agricultural land is used for growing Blue Gum wood for market, usually in groves of from 10 to 40 acres. Not only are these groves profitable, but they add much to a landscape which without them was quite monotonous. Land unsuitable for tillage—hillsides, ravines, and rocky plains—is also much utilized. In such cases the return from the fuel produced is practically a clear gain. In July, 1900, the writer's attention was attracted to a grove of Eucalypts near Pasadena, Cal. Subsequently, in response to an inquiry as to the age of the grove, Mr. H. F. Shorting wrote as follows:

> The *Eucalyptus globulus* grove is 12 years old, and is in the worst sort of soil, for grapes, oranges, lemons, and barley have all failed. It is an old river bed. It was cut one year ago, and they are far better looking trees now than they were before being cut. (Pl. VII, A.)

There is undoubtedly much land in the Southwest now considered too poor for growing any crop that might profitably be set to fuel-producing groves of Eucalypts.

When 5 to 7 years old, groves of Blue Gum or Manna Gum may be cut to the ground for fuel, and they may be cut every six or eight years thereafter. The yield from each cutting is commonly 50 to 75 cords of 4-foot wood per acre. One 17-acre grove between Los

Angeles and Compton, set in 1880 and cut for the third time in June, 1900, produced 1,360 cords, an average of 80 cords of 4-foot wood per acre. (Pl. VI, B.) The price received by the owner for the crop was $2.50 per cord on the stump. It will be seen that this return fully justified the using of the heaviest of agricultural land for the growth of fuel. On poorer land the yield is only a third to a half the above amount. The size attained in good soil a short time after being cut is often remarkable. (Pl. VII.) In a grove near Pasadena, set in 1885 and cut for fuel in 1893, there were in July, 1900, some trees 2 feet in diameter and many over 100 feet in height.

Mr. Cooper estimates that at the rate his trees are growing he can cut from his 200 acres of miscellaneous species, set largely in soil too rough for tillage, 1,000 cords of wood per year indefinitely without in any way detracting from the appearance of the groves or from their usefulness in other ways. Judged by the known rate of growth of smaller groves, the above estimate is not high. The Eucalypt is evidently destined to be the future fuel tree of the Southwest. Even when settlement in this region began the hard-wood trees were limited in number, and these are rapidly disappearing under the woodman's ax. In much of the Southwest the oak has been a source of hard-wood fuel, but in many places the supply is about exhausted, and in none can it last indefinitely. Over a good deal of the region the Mesquite (*Prosopis juliflora*) has been the chief source of fuel, but even these trees are rapidly disappearing in the vicinity of the settlements. All available timber will soon be cut, and there is no known species except the Eucalyptus that can take its place and at the same time supply the increasing demand for hard-wood fuel. The extensive planting of Eucalypts in such localities would be a wise provision for the future.

Not only the wood of the Eucalypts is used for fuel, but in California the leaves are utilized for this purpose. A Los Angeles company is making for market bricks composed of Blue Gum leaves and twigs mixed with crude oil, and the product is reported to be an excellent fuel for domestic use. The entire tree is thus utilized. This new use of Eucalypt leaves suggests the possibility of many industries growing out of the extensive planting of the trees in the Southwest.

AS A SOURCE OF OIL.

While the stem and branches of the Eucalypts furnish timber and fuel, the leaves and twigs are the source of a very important oil. In Australia many species yield sufficient quantities to enable them to be utilized for oil production, but most of the oil produced there is obtained from three or four species. For many years the production of eucalyptus oil has been an important industry in that country. One of the first investigators and producers of this oil was J. Bosisto,

of Melbourne. Baron von Mueller states in the Eucalyptographia that in 1880 Bosisto was producing 6 tons of oil per year. Since then the demand for the oil has increased very much, and a much larger quantity is produced in Australia annually. During the past ten years considerable eucalyptus oil has been produced from the Blue Gum plantations in Algeria, it having been found advantageous to obtain the oil from solid plantations of one species rather than from native forests where the species grow mixed. In California considerable oil has been extracted from the Blue Gum during the past five years. The principal producer is a physician in Los Angeles, who is attempting to establish a reputation for putting up a pure high-grade product. During the winter of 1900–1901 he extracted 9 tons of oil. He does not distill out any eucalyptol, as he considers the oil in the form he puts it out superior for most purposes. The residue from the distillation of the refined oil from the crude product is put up for a salve. From the oil he manufactures a soap and cough drops. Hon. Ellwood Cooper has a young Blue Gum plantation on his ranch near Santa Barbara, from which he intends to manufacture both eucalyptus oil and eucalyptol. He will cut the trunk and limbs into fuel, extract oil from the twigs and leaves, and thus utilize the entire tree.

The different species vary greatly as to the amount of oil they will yield, the range being from none to 500 ounces from 1,000 pounds of fresh leaves and twigs. According to J. Bosisto and other Australian authorities and S. M. Woodbridge, of Los Angeles, the Peppermint Tree (*Eucalyptus amygdalina*) yields the largest amount. But in America this tree is not grown extensively enough for it to be a source of much oil. For some years yet, and perhaps always, the chief source of eucalyptus oil here will be the Blue Gum. The yield of crude oil from the leaves and twigs of this species ranges from 1 to 1.6 per cent. Dr. Herron extracted, during the past season, 9 tons of oil from 700 tons of leaves and twigs from this species—a yield of 1.28 per cent. H. B. Silkwood, proprietor of the California Eucalyptus Works, Garden Grove, Cal., reports that he produced 1 ton of oil from 100 tons of material during the past year, the output being limited by the available supply of Blue Gum leaves. The Red Gum yields much less oil than the Blue Gum—only 10 to 30 per cent as much.

The oils from the different species of Eucalypts differ greatly. As extracted they are all compounds or mixtures. The chief ingredient of the oil from the Blue Gum is a colorless, transparent, camphoraceous liquid called eucalyptol or cineol; of the Peppermint Tree (*Eucalyptus amygdalina*), a less known liquid called phellandrene; of the Lemon-scented Eucalypt (*E. citriodora*), a fragrant, highly volatile liquid called citronellon, mixed with another fragrant liquid called geraniol. Several other ingredients enter into the composition of the oils from the various species. The best known of all the ingre-

dients is eucalyptol, which constitutes about 60 per cent of the oil from the Blue Gum.

The medicinal properties of the various component parts of eucalyptus oil differ widely. Hence the oils from different species have very different medicinal values. Unless eucalyptol, the chief ingredient of Blue Gum oil, has the same effect upon the human system as phellandrene, the prominent ingredient of the Peppermint Tree oil, the oils from these two trees must necessarily have different medicinal properties, and the oil from a forest of mixed species must have very uncertain medicinal properties. The Eucalyptus oil produced in America, where the groves from which leaves are obtained for oil are commonly of one species, and where, with rare exceptions, a single species (Blue Gum) is the source of all the oil extracted, will necessarily be a product whose properties are better known and more constant than that produced from mixed native forests. Hence the importation of eucalyptol or Eucalyptus oil from Australia or elsewhere is both unnecessary and a disadvantage to the consumer. As Hon. Abbot Kinney remarks in his "Eucalyptus":

> The increased use of the eucalyptus oils derived from the solid plantations of *E. globulus* in California and Algiers is thus seen to rest upon reasonable grounds and must give increased reliability to medicinal preparations from the Eucalyptus.

Eucalyptus oil is so useful, and popular information concerning it is so meager, that a few words concerning it will not be out of place here. This oil has been used for about forty years, but only during the past ten years has it been employed in medicine very extensively. Its use is now constantly increasing, as its properties and medicinal value become better known. All druggists questioned on the subject stated that the demand for Eucalyptus oil was rapidly increasing. Two wholesale druggists of Los Angeles both stated in letters to the writer, written in response to inquiries on this point, that their sales of the oil had increased very much during the past few years.

The fact that it is nonpoisonous and nonirritant makes it especially safe and valuable. As much as a fourth of an ounce has been taken internally without injury, and it may be freely applied to the most delicate tissue. Notwithstanding the fact that it is neither dangerously poisonous nor irritating to the human system, it is a very effective antiseptic and disinfectant, and has come to be used quite extensively for dressing wounds, ulcers, and other diseased tissues. It enters into the composition of several antiseptic preparations. The oil is also a well-known remedy for malarial and other fevers, and is used in treating diseases of the skin, and of the stomach, kidneys, and bladder, and is especially valuable for affections of the throat, bronchi, and lungs.

In using Eucalyptus oil it is important that a pure article be procured. Unfortunately there is considerable adulteration of this oil with cheaper, inert, or harmful ones. No doubt this remedy would

A. EUCALYPTUS GONIOCALYX. TREES 24 YEARS OLD.

B. EUCALYPTUS TERETICORNIS. TREES 22 YEARS OLD.

EUCALYPTS ON RANCH OF ELLWOOD COOPER, SANTA BARBARA, CAL.

EUCALYPTUS HEMIPHLOIA. TREE 4 YEARS OLD, EXPERIMENT STATION FARM, PHOENIX, ARIZ.

EUCALYPTUS HEMIPHLOIA. TREES 24 YEARS OLD, COOPER RANCH, SANTA BARBARA, CAL.

be a more popular one but for the fact that so much of the oil for sale on the market is of such an uncertain nature. The safest way is to purchase none in bulk, but buy it in bottles put up by a reliable person or firm. It costs more in this form, but is far safer to use as a remedy.

The leaves of the Blue Gum and of a few other species, on account of the oil they contain, are employed as household remedies in localities where the trees grow. Among the natives of Australia they are said to be in common use for dressing wounds and for other purposes. In California, teas and poultices are made from the Blue Gum leaves for treating colds, wounds, and ulcers. The leaves are also steamed for the treatment of colds, catarrh, croup, bronchitis, and other affections of the respiratory system. Some go so far as to use regularly tea made from the leaves of Blue Gum, and, as they assert, with beneficial results.

AS A SOURCE OF HONEY.

The Eucalypts generally bloom so freely and so early in their development that as a group they are an important source of nectar for bees. The fact that some species can be found in bloom any day of the year, often during droughts when other blossoms are scarce, in many cases in great profusion, makes them especially valuable as a constant source of bee food. Mr. Kinney, who has made extended observations on the blooming of the Eucalypts, writes in his "Eucalyptus:"

> Taking the sixty species and marked varieties of this genus in southern California, I have never seen a day that flowers could not be found on some of them. * * * When we consider the free production of nectar by the Eucalyptus at seasons when there is little or no other resource for bees, and also the claimed medicinal value of honey from Eucalyptus flowers for relieving irritation from the mucous membrane, and as a nerve sedative, the presumption is strongly in its favor. Bee men will doubtless find it to their interest to study the species, and plant in waste places such sorts as will furnish the best kinds of nectar during the most difficult season for the bees. * * * I believe that by some study of this subject species of Eucalyptus with plenty of nectar could be so selected as to give a constant crop of flowers or flowers at such times as these are absent in other plants.

Naudin, in his "Description and Use of Eucalyptus," says of their value as a source of honey:

> Another use of the Eucalyptus * * * is supplying the bees with abundant provisions for food by their flowers, from which they withdraw a perfumed honey, endowed perhaps with peculiar hygienic properties.

Whether or not the Eucalypts give a peculiar medicinal quality to the honey may be a question, but it is certain that they are a valuable pasture for the bees.

Since Mr. Kinney wrote the above, beekeepers have become more interested in the Eucalypts as a source of nectar. William Shutt, foreman of the Santa Monica Forestry Station, informs the writer that

he receives many inquiries concerning the merits of certain species for bee pasture. In a subsequent portion of this publication will be found a list of the species useful for this purpose. In planting trees for forest cover, wind-breaks, shade, timber, or fuel it would be well, wherever the bee industry is important, to select varieties recognized as flower producers. Several species valuable for the purposes mentioned above—notably the Sugar Gum (*Eucalyptus corynocalyx*), the Red Gum (*E. rostrata*), the Red Iron bark (*E. siderorylon*), *E. hemiphloia*, and *E. polyanthema*—are profuse bloomers and are thronged with bees during the blooming season, which with some species is quite protracted.

AS IMPROVERS OF CLIMATE.

The Eucalypts have the reputation of benefiting the climate of those regions where they have been planted. Evidence upon this subject is so conflicting, however, that the truth is ascertained with difficulty. Whatever the fact may be, the belief is quite general, especially in southern Europe, that the effect of Eucalypts upon the climate is distinctly sanatory.

The plantation of Eucalypts at Tres Fontane, in the Roman Campagna, is the instance most generally cited by those who contend for the beneficial influence of these trees on the climate. In fact, the general planting of Eucalypts throughout southern Europe seems to have been given a decided impetus by reports of the results at Tres Fontane. On this point Charles Belmont Davis, American consul at Florence in 1894, writes in Consular Reports No. 168 as follows:

> It is this latter quality [the property of distributing a balsamic atmosphere] which has brought the Eucalyptus into such prominence in Italy, and has been the cause not only of the planting of thousands of trees by private individuals and public corporations, but of its receiving the indorsement of the Italian Government as well.

He adds:

> Whether the plant does absolutely contain such a healthful quality as many attribute to it has always been and still is a question in the minds of many who have given the subject intelligent thought and systematic experiment. That the planting of these trees has met in some districts with a degree of success in allaying the ravages of malaria there would seem to be little doubt.

In the consular report mentioned above Wilbur B. Hall, American consul at Nice, writes:

> The Eucalyptus seems destined to revolutionize silviculture in the countries mentioned [France, Algeria, Italy, Spain, Corsica, Portugal, and Cape Colony], not only on account of the many remarkable properties of the tree, its resin, its wood, and its rapid growth, but also its great power of absorbing enormous quantities of water from wet and swampy lands, drying them and rendering them fit for cultivation, as well as its tendency to thus eliminate malarial conditions from the lands whence it grows.

M. Carlotti, who has studied Eucalypts exhaustively on the island of

Corsica, in his "Rendering warm, unhealthy regions healthy by means of the Eucalyptus," cites a large number of instances of improved climate attributed to the planting of Eucalypts.

M. Lambert makes similar statements as to the effect of planting these trees in Algeria. M. Gimbert also cites examples of the improvement of climate in Algeria, as well as in Cape Colony and other parts of Africa, due to the planting of Eucalypts. It is asserted by many Californians that the planting of Eucalypts has diminished the amount of malaria in central California. Others in various parts of the world have made similar claims.

On the other hand, some who have investigated the subject maintain that the fact of the improvement of climate by Eucalypts is not established. Perhaps the ablest of those who have combated the popular belief in the sanatory effect of Eucalypts is Prof. Tomaso Crudeli, who has investigated the subject carefully in Italy. He insists that up to the date of his writing (1886), "not a single instance of hygienic improvement by the sole means of Eucalypti has been ascertained, but the possibility of so doing is not denied."

Wallace S. Jones, American consul at Rome in 1894, writes as follows in Consular Report No. 168:

> In Italy, although the newspapers had persuaded everyone that the farm of the Tres Fontane, near Rome, had become healthful by means of the Eucalypti, it proved a disagreeable surprise to learn of a sudden outbreak of malaria in 1882 that caused much sickness among the farm hands, while the rest of the Campagna remained perfectly healthy. * * * Dr. Montechiare, a practicing physician of Rome, who for years was physician to the penal colony at Tres Fontane, tells me that his experience justifies him in declaring that no beneficial result against malaria has been derived from the planting of the Eucalyptus.

Those who fail to recognize the beneficial effects of the planting of Eucalypts also call attention to the fact that malaria prevails in many parts of Australia where these trees are abundant. It seems to be admitted, however, that malaria is absent, or at least not prevalent, in those parts of Australia where the Blue Gum, the species that is believed to have produced the beneficial result about the Mediterranean, is native or thrives. Whether this coincidence, if such it be, is due to the natural climate or to the effects of these trees would be somewhat difficult to decide.

It is probable that considerable of the change in the sanitary condition of those places said to have been benefited by Eucalypts has been due to other causes, such as the making of drainage ditches, etc., and this will partially account for the conflicting opinions on the subject. When, however, the nature and habit of the trees are considered, it is entirely reasonable to believe that to a certain extent they beneficially affect the atmosphere in the region of their growth. The grounds for this belief are: First, their great capacity for absorbing moisture from the soil, and thus reducing the quantity of stagnant

water in the ground at their roots; second, their corresponding power of giving off fresh from their foliage the water thus taken up by their roots; third, the exhalation from their leaves and other parts of volatile oils, which affect the climate not only directly but by changing the oxygen of the atmosphere to ozone; fourth, the purification of germ-infested matter by the foliage dropped upon the ground or in pools of standing water. From the combined action of these four characteristics is seems reasonable to believe that the trees would be beneficial to many climates.

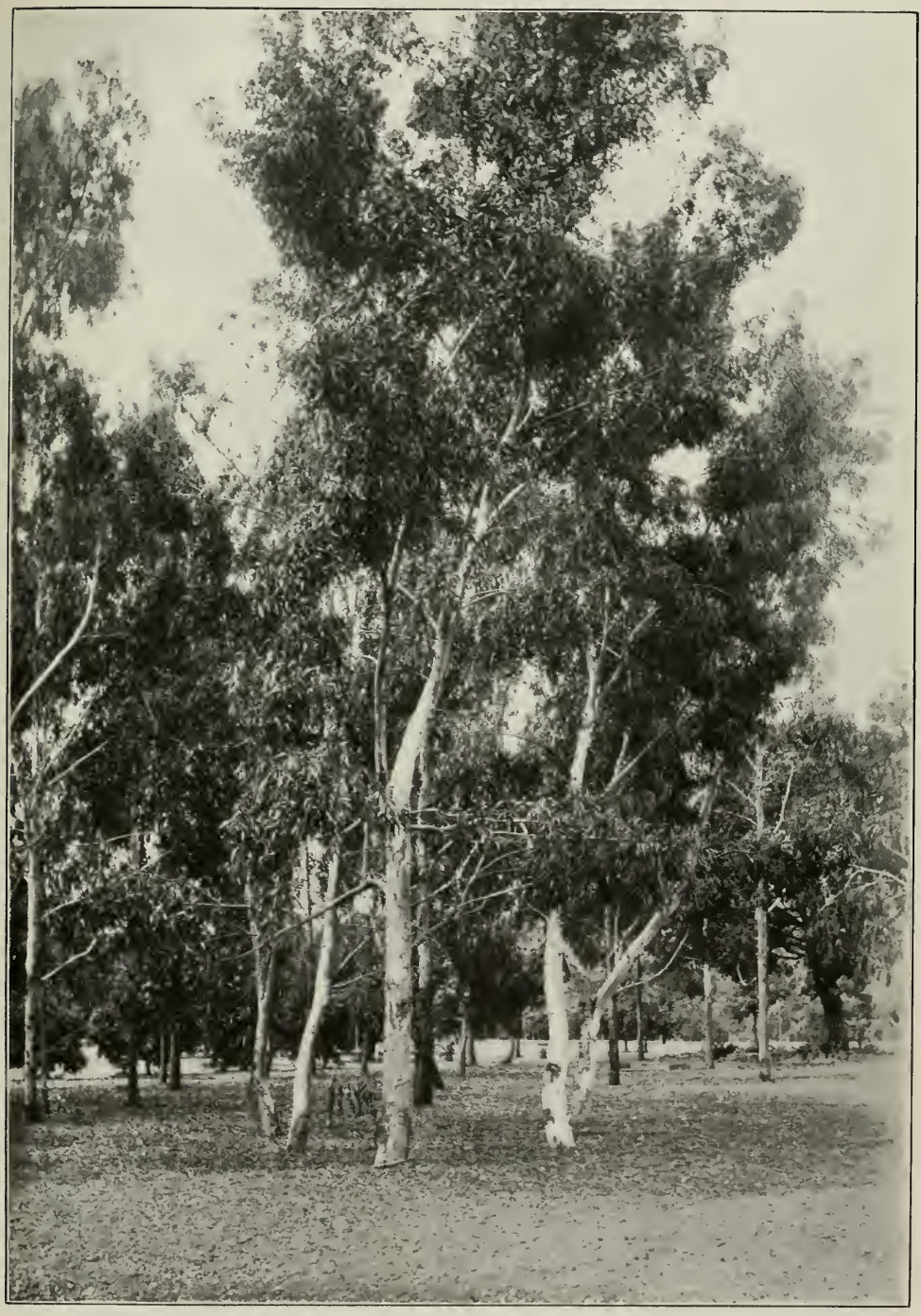
It is not necessary to determine, however, before setting Eucalypts, whether they have a pronounced beneficial effect upon climate or not. They certainly do not injure a climate. They serve so many other useful purposes that the question as to their effect upon climate may be waived, and the planting of them still go on from other motives. The belief that they improve climate has served a useful purpose regardless of the facts in the matter. The planting of trees is such a desirable thing that it matters little what the motive for planting them be, provided they get planted. Eucalypts may confidently be grown for a forest cover, for wind-breaks, for shade, for timber, for fuel, for the oil and the honey they furnish, and if, at the same time, they improve the sanitary condition of the region in which they are growing, the reward of the planter will be so much the greater.

PROPAGATION AND CARE OF EUCALYPTS.

DIFFICULTIES IN GROWING SEEDLINGS.

Eucalypts are less easily propagated in America than most other forest trees. This is due in part to the smallness of their seeds and the infertility of many of them, and in part to the fact that each species requires, or at least prefers, certain peculiar climatic conditions. Few grow spontaneously in the Southwest yet, and none do so freely. The Red Gum and the Blue Gum are occasionally found growing spontaneously from fallen seed, and at Mr. Cooper's ranch near Santa Barbara Red Gum seedlings were seen by the writer in abundance under trees in shaded canyons, and in washes below the trees. (Pl. VIII.) Mr. Cooper also pointed out trees about a foot in diameter that had grown from volunteer seedlings. Southwest of Los Angeles, near the ocean, where the temperature is even and the atmosphere more humid than farther inland, young seedlings often appear in the groves of Blue Gums, and this occurs in similar situations in central California, being very noticeable on the university campus at Berkeley. On the Minnewawa ranch, near Fresno, seedlings of *Eucalyptus rudis* appear under the trees in abundance each spring, and are used by the owner for planting. (Pl. VIII, B.)

In some regions species which grow fairly thriftily when once started



EUCALYPTUS LEUCOXYLON, STATE FORESTRY STATION, SANTA BARBARA, CAL.

EUCALYPTUS LEUCOXYLON. TREE 10 YEARS OLD, CAPITOL GROUNDS, PHOENIX, ARIZ.

EUCALYPTUS LONGIFOLIA. PASADENA, CAL.

EUCALYPTUS MELLIODORA, STATE FORESTRY STATION, SANTA MONICA, CAL.

are propagated from the seed with great difficulty. For example, the Red Gum (*Eucalyptus rostrata*), which grows quite well in southern Arizona from seedlings obtained from California, is propagated at Phoenix from seed with considerable difficulty. The case is similar to that of the orange tree, which, though thriving in the vicinity of Phoenix can not be easily grown there from seed. As a rule, however, Eucalypts that are well adapted to a region and thrive in it seem to be fairly easy to propagate there. The ease with which seedlings can be grown in any region may often, therefore, be taken as an indication of how well the adult trees will grow there.

Eucalypts are not commonly propagated in open soil, but in seed boxes, and ordinarily they need some protection from cold and from the sun during their early stages. Most species make a slow growth at first and are quite delicate, but when once fairly established they grow very rapidly.

PLANTING THE SEED.

The usual method of starting Eucalypts is to sow the seed in shallow boxes in especially prepared soil. A mixture of coarse sand and leaf-mold (two parts of mold to one of sand) is the best. This is placed in boxes a few inches deep; the seed is strewn quite thickly over the surface; a light covering of sand is placed on top, and this surface is then kept constantly moist. The young plants commonly appear in one or two weeks. After germination has taken place the soil should be kept moist but not wet. If kept too damp the young plants will be attacked by parasitic fungi and perish rapidly—"damp off," as gardeners term it. Applying the water about the middle of the forenoon, so that the soil and plants have time to become partially dry before night, is a precaution helpful in preventing damping off. In the experience of the writer there is nothing better for freshly sown seed, or for young plants, than a watering by a rainfall. Leaving the seed boxes out during a light rain will often start seed that artificial watering for weeks has failed to bring up, and young plants are very much refreshed and invigorated by a shower of rain.

Before transplanting it is well to harden the young plants by giving them only sufficient water to prevent wilting during the heat of the day. After a week or so, when they have become more woody, water should be applied freely for a few days, and they will then be in a better condition for transplanting than if this treatment is omitted.

TRANSFERRING TO FRESH SOIL.

When the young seedlings are 2 or 3 inches high, they should be transplanted into flats of fresh soil, putting in the plants about 2 inches apart each way. (Pl. IX, A.) This soil may contain less sand and more leaf mold than the seed bed. A mixture of leaf mold, sand, and

some soil similar to that in which they are to be set in the field is a good combination. If the plants are few and choice, it is usually best to transfer them from the seed bed to pots instead of to flats. From the pots they can be transplanted with less loss than from the boxes. They still need frequent watering, but the surface of the soil does not need to be kept as moist as during the earlier stages of growth. For a few days after being transferred they often need additional protection from drying. When they have become well established it is well to expose them to the sun and the outdoor air sufficiently to harden them before transplanting to the field.

The work of propagating Eucalyptus seedlings is not always accomplished successfully by those without experience in gardening or greenhouse work. Where the climatic conditions are at all trying, unless one has had some experience in propagating evergreen plants from small seeds, it will be better to purchase the trees of a grower. In the dry valleys of the interior it is especially difficult to grow young Eucalypts successfully. So many are lost from various causes, but largely because of the dryness of the atmosphere, that it will be found more economical to procure the plants from some grower located in a more favorable region.

But it is important that plants be purchased of a reliable grower. The species of Eucalypts are so numerous, the seeds so small, and the different species so similar in the earliest stages of growth, that it is easy for honest confusion to arise in the mind of a grower who is not conscientiously careful. When to this is added unscrupulousness, the danger of not getting the species desired or called for is quite great. The Blue Gum seedlings are so well known that growers or buyers are seldom deceived in them. But it is not safe to buy any other species of any but a thoroughly reliable grower. Many nurserymen, if they have not the species called for, or are so ignorant as to be unacquainted with it, will substitute some entirely different species, thinking the purchaser will not know the difference, at least for some years. Last spring (1901) a Los Angeles nurseryman sold a farmer plants of *Eucalyptus robusta* for both Sugar Gum (*E. corynocalyx*) and Red Gum (*E. rostrata*), the former in cans and the latter in flats.

SETTING IN THE FIELD.

When the seedlings are from 4 to 8 inches high they are right for setting in the field. (Pl. IX, B.) They usually attain this size when they are from 4 to 6 months old, but species vary considerably as to the time required to bring them to the given size. They bear transplanting better, and make a better start after being set out, at this age, than they do when older and larger. In some parts of the South and Southwest they can be set out in the field almost any time during the year. In other localities it is difficult to get them started in the

field except during certain seasons. In California they are commonly set out from February to May, but may be set considerably earlier or later in many parts of the State. Where heavy frosts occur during the winter it is best to wait until the danger of their occurrence is over, as many Eucalypts that endure frost when older are quite sensitive when young. In southern Arizona the best months for setting are March and April, just after the winter rains, and July and August, during the summer rains. They can be started most successfully there during the latter part of March.

If the Eucalypts are being set primarily for shade they may be set in single or double rows, 10 to 20 feet apart in the rows, along fences or irrigating ditches, or on each side of a road; or they may be scattered about the barnyard or the stockyard. But if they are being set for timber or for fuel it is best to set them 8 to 16 feet apart each way in solid blocks. When set in this manner they grow straighter (thus making more serviceable timber), split more readily for fuel, and are in every way more useful than if they grow scattered about and exposed to distorting winds. Some species, like the Red Gum, that are slender and easily distorted by the wind the first year or two, will grow straighter if corn be planted among them. In regions where the sun is trying the corn serves as a partial shade, as well as a wind-break. But as stated before, Eucalypts thrive best in bright sunlight, and it is not well to permit the corn to encroach too closely upon the young plants.

SUBSEQUENT CARE.

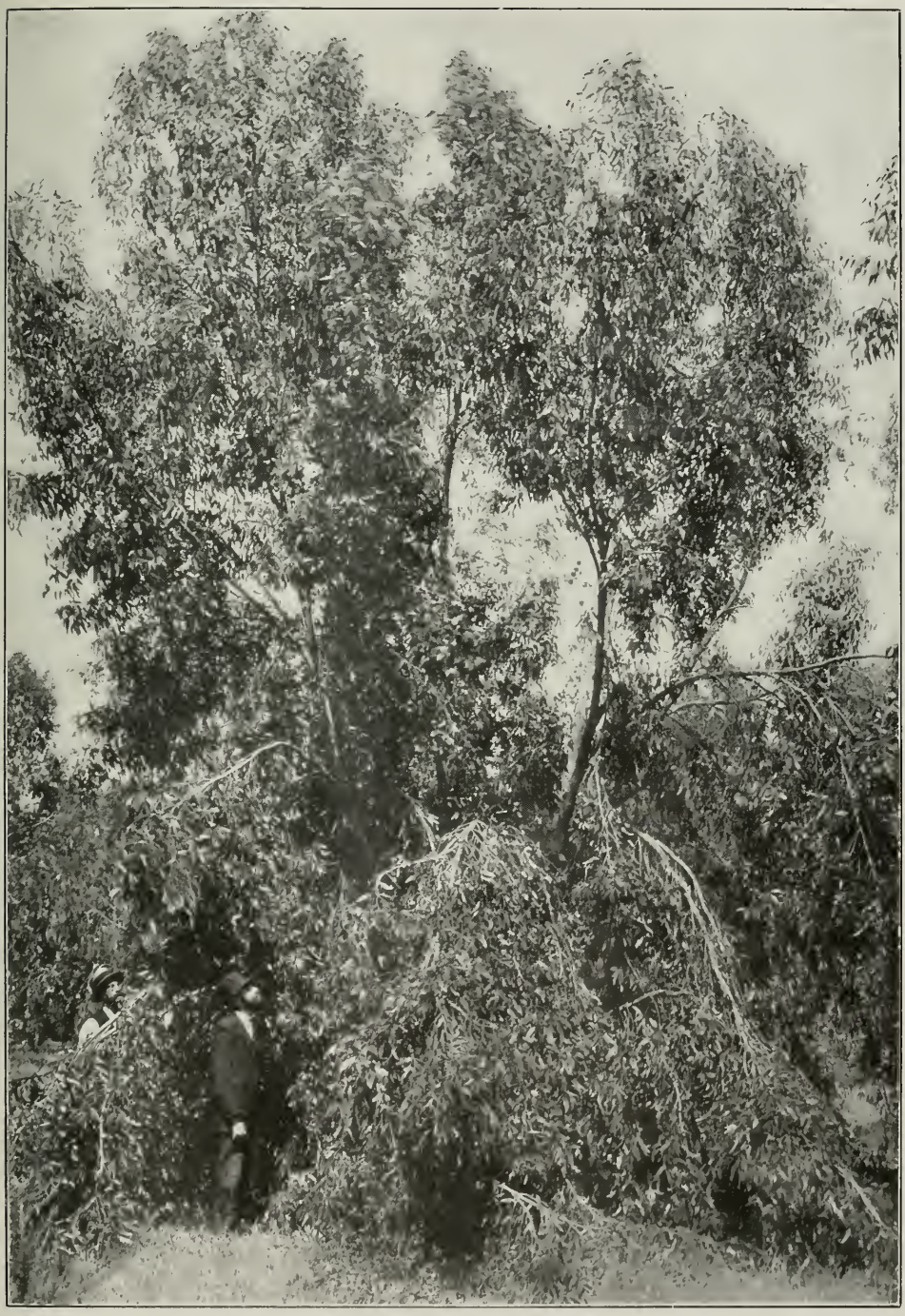
The young plants should be given some water when set out, and in many cases the watering will need to be continued for some time. How long after setting the application of water should continue will depend upon the climate, and upon the weather that follows. In the coast region of California, where night and morning fogs are frequent, little artificial watering is necessary. Farther inland trees need to be watered for several weeks at least. In the dry valleys of southern Arizona, New Mexico, and Texas they should be irrigated at least throughout the first season, and will make more satisfactory growth if irrigation be continued several years. After their root system is well established a few irrigations during winter when water is abundant will be all they they will need in most of this region. If set along irrigating ditches or canals it will be necessary to water them by hand only a few months, until the roots have pushed down into the permanently moist soil.

As most of the Eucalypts are quite delicate plants when small, they will need careful attention the first season. They should be cultivated and kept entirely free from weeds for from one to three years, according to the species and the condition of the soil. In many cases they

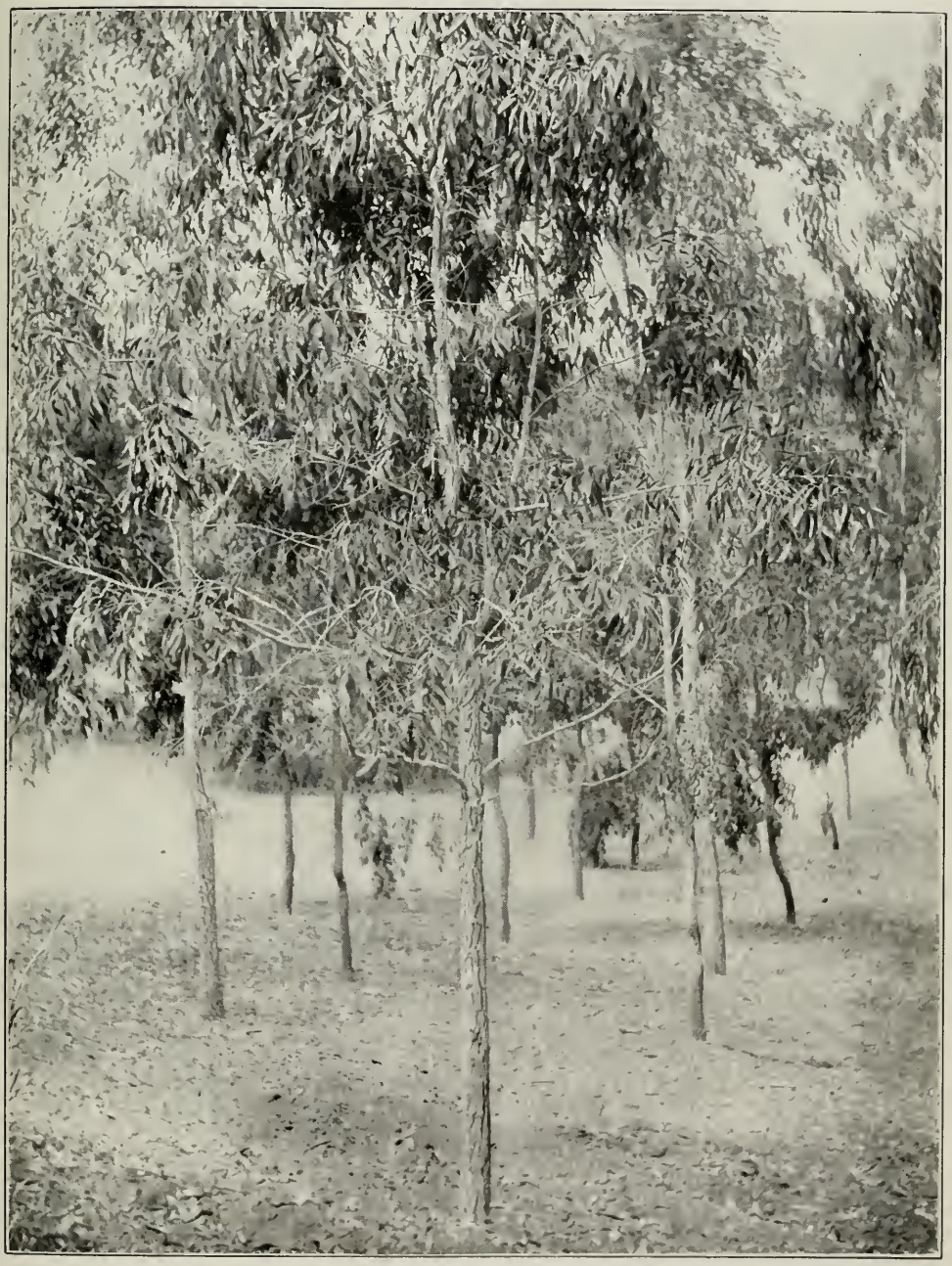
will need some protection from animals. Rabbits and other rodents sometimes nibble off young plants. If these animals can not be destroyed or excluded from the field, it will be necessary to protect each seedling from their ravages by means of a sheath of woven wire or other suitable material.

The great usefulness of the trees and the considerable length of time they are likely to remain where planted warrant the planter in giving the young plants all the attention they need until they become established. The Blue Gum is one of the easiest of the genus to start and needs less attention than most species, but it should be cultivated and protected from rodents for at least the first season. Any species should be given at least as much care as would be given a field of corn. The cost per acre for the care of the young seedlings need not be much greater than the cost of caring for a corn crop. To set young trees and then leave them to struggle with weeds, to suffer for want of water, or be injured by animals is not economical. Eucalypts, like most trees, will endure quite unfavorable conditions when once established, but they need careful attention until they become thus fitted to cope with such conditions.

EUCALYPTUS MICROTHECA, MONTECITO, CAL.



EUCALYPTUS OCCIDENTALIS, NEAR SANTA MONICA, CAL.



EUCALYPTUS PANICULATA, STATE FORESTRY STATION, SANTA MONICA, CAL.

EUCALYPTUS PILULARIS, NEAR SANTA MONICA, CAL.

PART III.

PRINCIPAL SPECIES OF EUCALYPTS GROWN IN AMERICA.

In discussing the following species of Eucalypts the aim has been to use as few technical terms as possible. However, the species of the genus Eucalyptus are so numerous (about 150), and have been known to the civilized world for such a comparatively short time, that satisfactory popular names have not yet been assigned to many of them. Hence, it has been necessary to head the discussion of each species with the scientific name, adding whenever practicable a common name.

To be sure, the majority of species discussed here are known to have names applied to them by the aborigines of Australia, and the English colonists have assigned names to most of them. But the different native tribes, and the colonists as well, have different names for the same species. For example, *Eucalyptus microtheca* has seven known native names and six colonial ones; and *E. viminalis* and *E. amygdalina* are each known by nine different colonial names. To add to the confusion, the same English name is applied to many different species. As illustrations of this, the term "Blue Gum" is applied to twelve species; the term "Flooded Gum" is applied to seven species; the term "Ironbark" to eight species; the name "Red Gum" to nine species; the name "Stringy-bark" to eleven species, and the name "White Gum" to thirteen species. As Abbot Kinney observes in his work "Eucalyptus," each district in Australia has a nomenclature of its own for the Eucalypts, and thus the common names are, with few exceptions, confused and uncertain.

As there are already over fifty different species of Eucalypts grown in America it will undoubtedly be a good many years before many of them will be known popularly by well-established common names. In the meantime it will be necessary to continue using the scientific names in order to designate them accurately. *Eucalyptus globulus*, on account of its predominance in the Southwest, has come to be well known as the Blue Gum, but at least one of the eleven other species known by this name in Australia, which is also a promising species for parts of America (namely, *E. leucoxylon*), is entitled on account of its general aspect to be known here by this same name. If by common consent the latter could come to be known as the "White Gum," in reference to the white bark and wood of the tree (the specific name, leucoxylon, meaning in

Greek "white wood,)" as it is known in parts of Australia, the prospective difficulty would be obviated. A name concerning which there is considerable confusion is "Red Gum." Probably the species most entitled to it is *E. rostrata*, but both in Australia and America the name "Red Gum" is applied to several additional species for which there is no other good popular name. In America the name "Sugar Gum" has been applied to *E. corynocalyx* alone, so far as known; and the term "Manna Gum," so far as it has been used at all, to *E. viminalis* alone. *E. cornuta*, and this species alone, is known here to some extent as the "Yate," and the name "Bloodwood" seems to be applied to *E. corymbosa* only. But few, if any, others of the fifty or more species growing in America are yet known widely by any common names.

Consequently, the reader of this publication, and growers of the species for some years to come, will have to bear patiently with the use of the botanical names of the species. There will be no great hardship or inconvenience in doing this, as most of the names are quite expressive, referring to some prominent feature of the trees. For example, *calophylla* means "beautiful leaved;" *coriacea* means "leathery," referring to the leaves; *corynocalyx* means "club-shaped calyx;" *cornuta* means "horned;" *diversicolor* refers to the diverse colors of the two sides of the leaf; *globulus* refers to the globular seed-cases; *goniocalyx* means "angled calyx;" *hæmastoma* means "bloody or red mouthed;" *leucoxylon*, "white wood;" *longifolia*, "long leaved;" *citriodora*, "citrus odored" (referring in this case to the citrus fruit, lemon); *melliodora*, "honey odored;" *microtheca*, "small seed-case;" *obliqua* refers to the oblique leaves of the tree; *polyanthema*, "many flowered;" *punctata*, "dotted;" *resinifera*, "resin-bearing;" *robusta* refers to the robust appearance of the tree; *rostrata* refers to the rostrate or beaked flower buds; *saligna* means "willow wood;" *sideroplhloia* means "iron bark;" *sideroxylon*, "iron wood;" *tereticornis* means "round-horned," referring to the terete or cylindrical flower buds, and *viminalis* means "osier willow." The termination "oides" means "like," the specific name *acmenoides*, for example, meaning "acmen-like;" *botryoides* meaning botrys or grape like, (referring to the clusters of the seed-cases), and *eugenioides* meaning "Eugenia-like," referring to Eugenia, a plant genus of Australia. A few specific names (and fortunately only a few of those applied to Eucalypts generally planted) are Latinized forms of proper names, having been assigned by the namer and describer in honor of some botanical worker. For example, *Eucalyptus gunnii* is the Latin for "Gunn's Eucalypt;" and the name *stuartiana* was assigned in honor of a collector named Stuart. *Eucalyptus*, the name of the genus, means, as has been stated, "well concealed," referring to the complete manner in which the essential organs of the flower are covered.

The paragraphs giving the characteristics of the several species discussed were all written or revised under typical trees of the respective species. It is hoped that they are sufficiently accurate and explicit to enable a planter, aided by the illustrations, to decide more or less definitely whether a particular tree in question is what it has been represented to be, or is supposed to be. If there is no clue to the name of a tree, the name of which is desired, it will be necessary to resort to the use of the keys and descriptions given in the botanical section of this bulletin. For this work a good hand lens and some knowledge of botanical terms are essential.

The climatic requirements of the Eucalypts described here have been determined mainly by personal observation and experiment in the Southwest. In some cases, where the species has been cultivated only to a limited extent in America, inferences in regard to the climatic requirements of the tree have been drawn from its native habitat. This is not entirely safe; but an attempt has been made to make statements based on such data very guardedly, as it can not always be prophesied from a knowledge of the native environment of any particular species just how it will behave in a foreign country. The maximum temperatures given as the degree of heat a species will endure are those recorded in the shade 5 feet from the ground by a self-recording thermometer.

The information given concerning the uses of the several species is drawn largely from Baron von Mueller's "Eucalyptographia" and "Select Extra-tropical Plants," Mr. Maiden's "Useful Australian Plants" and "Commercial Timbers of New South Wales," and Mr. Bailey's "Queensland Woods," since most of the species have not been grown in America long enough nor planted extensively enough to furnish independent data concerning many of the uses of a large number of the species. A notable exception to this is the Blue Gum (*Eucalyptus globulus*), which has already been used for a great variety of purposes, including wind-breaks, forest cover, shade, fencing, piling, fuel, and oil. A few others have been used for fuel and for timbers. The only useful purposes that many of them have yet served in America are as shade trees, wind-breaks, and bee pasture.

Eucalyptus amygdalina.

GIANT EUCALYPT; PEPPERMINT TREE.

Characteristics.—In its native country the individuals of this species are the tallest of the genus, and probably the tallest trees in the world. In his "Eucalyptographia," Baron von Mueller says of this species:

This Eucalyptus is one of the most remarkable and important of all the plants in

the whole creation! Viewed in its marvelous height when standing forth in its fullest development on the slopes, or within glens of mountain forests, it represents probably the tallest of all trees of the globe; considered as a hard-wood tree of celerity in growth, it ranks among the very foremost; * * * and contemplated in respect to the yield of volatile oil from its copious foliage, it is unsurpassed and perhaps not equaled by any other tree in the whole world.

He speaks of recorded heights of over 400 feet and of diameters of 18 to 35 feet. One tree furnished a log 220 feet long, 12 feet in diameter at the top, and 30 feet in diameter at the base—an immense stick of hard-wood timber! While claiming that this Eucalypt is the tallest tree in the world, Baron von Mueller admits that in respect to height combined with diameter "it must cede the palm of superiority perhaps" to the Sequoias of California. In most other countries outside of Australia, this Eucalypt has not attained extraordinary heights; nor does its rate of growth prophesy great size. (Pl. X.) In the Southwest many other species grow more rapidly and have attained greater height since their introduction.

The tree is a very variable one, the size and habit depending upon the soil and the climatic environment. The great heights mentioned are attained in cool, moist ravines. Baron von Mueller says that in more open country it is of much lower stature, in some cases being comparatively a dwarf. It is the latter form that is known as "Peppermint Tree." In the Southwest it is exceedingly variable, running into forms that are evidently worthy of varietal names. The bark is also quite variable, being either rough and persistent or flaking off and leaving a smooth, yellowish surface. The trunk is fairly erect, but the small branches usually droop willow-fashion. The leaves are of medium size, varying from very narrow to lance-shaped. They are usually more or less curved. The narrow leaves are quite thick, the wider ones thinner. They are equally green on the two sides, and commonly have a distinct odor of peppermint when crushed. The flowers are small, in compact clusters of 8 to 15. The seed cases are small and nearly top-shaped. (See Pl. L.)

Climatic requirements.—The tree endures low temperatures, but is injured by dry heat. It does best near the coast and at moderate elevations in well-watered mountain regions. In no part of the Southwest do the requirements seem fully met.

Uses.—The timber is not so valuable as that of many other Eucalypts, but is said to be useful for shingles, rails, and for planking in ships. It is comparatively light, unlike many other Eucalypts, floating on water. It does not usually last well underground, nor does it furnish fuel of good quality. The leaves are a source of Eucalyptus oil. Baron von Mueller states that the fallen leaves of this and some other species deodorize the soil. He recommends the planting of it in swampy fever regions, where climatic conditions are suitable.

EUCALYPTUS POLYANTHEMA, ON GROUNDS OF GEORGE C. ROEDING, FRESNO, CAL.

EUCALYPTUS ROBUSTA, NEAR SOUTH PASADENA, CAL.

EUCALYPTUS ROSTRATA. TREES 8 YEARS OLD, EAST LAKE PARK, LOS ANGELES, CAL.

EUCALYPTUS ROSTRATA. TREES 24 YEARS OLD, NEAR OCEAN BLUFF, SANTA BARBARA, CAL.

Eucalyptus botryoides.

BASTARD MAHOGANY.

Characteristics.—The tree reaches a fairly large size (75 to 150 feet high when fully grown), making a vigorous growth when young. (Pl. XI.) It is consequently a handsome tree during the early years of its growth, and when fully grown is very stately in appearance. (Pl. XII.) The bark of the stem of the young tree is quite smooth, but that of the lower part of the trunk of the adult trees is rough, commonly persistent, and of a dark-gray or brownish color. The bark of the branches and of the young trees flakes off, leaving a smooth greenish or yellowish surface. The leaves are horizontally placed and are rather large and thick, having a dark-green, shiny upper surface, with a much paler under surface, the veins spreading like the parts of a feather. The flowers are stemless, above medium in size, in close clusters of 4 to 10, on rather stout, flattened stalks. The seed cases are cup-shaped or goblet-shaped, of rather large size, in compact clusters. (See Pl. LI.)

Climatic requirements.—This species thrives in a coast region, but is not suited to regions having a dry climate. In Australia it seems to prefer moist, sandy situations close to the seacoast, and, according to Baron von Mueller, will thrive in a soil containing stagnant water. In California it grows successfully in quite a variety of situations within 50 miles of the coast, having been quite extensively planted about Santa Barbara and Montecito, where it does well.

Uses.—This tree is one that can be used as a forest cover for lowlands in moderately humid regions where heavy frosts do not occur. On account of the nature of the foliage it is useful as a shade tree in many situations. The timber is called "swamp mahogany" and "bastard mahogany" in Australia, where the colonists of different sections hold it in differing degrees of esteem. Mr. Maiden thinks the latter may be due to a confusion of names. Mr. Bailey and Baron von Mueller both report the timber to be valuable, while Mr. Maiden speaks of it as "an inferior hard wood, both on the score of strength and durability." Baron von Mueller and Mr. Bailey report the timber as tough, hard, and durable, useful for beams in large buildings, knees of boats, for posts, for the parts of wagons, and for shingles. The wood is of a reddish color and close-grained. Baron von Mueller states that posts formed of it are very lasting, no decay having been observed after fourteen years of use.

Eucalyptus calophylla.

Characteristics.—This is a moderate-sized tree, differing considerably in appearance from most other Eucalypts. (Pl. XIII.) The bark is rough, and grayish or brownish in color. The broad leaves are

horizontally placed, dark green and glossy above, and feather-veined, their appearance giving the tree its specific name *calophylla*, the Greek for "beautiful leaves." The flowers are unusually large for the genus, commonly cream-colored, in large clusters. The urn-shaped seed cases are the largest of any Eucalypt, being rivaled only by those of *E. ficifolia*, to which it is closely related, the most conspicuous difference being in the bright red flowers of the latter. As the seed cases persist for some time, they are a conspicuous feature of the tree. The seeds are large and the seed leaves of the young plants consequently unusually prominent. The young seedlings are hairy for some time, the leaves differing in a striking manner from the glossy ones of the adult tree. (See Pl. LII.)

Climatic requirements.—*Eucalyptus calophylla* thrives best in a moist, tropical climate, enduring neither a hot, dry atmosphere, nor low temperatures. In America it has succeeded only in the warm coast regions, failing entirely in the dry interior plains and valleys. In no locality has the rate of its growth been such as to give promise of much usefulness as a forest tree.

Uses.—The species furnishes a valuable timber, said to be used in Australia much as hickory is in the United States, but the wood is reported as not durable underground. It yields a large amount of kino, and in Australia the bark is used in tanning. On account of its profuse bloom the tree is an important source of nectar for bees. In California the large seed cases have been polished and used for pipe bowls.

Eucalyptus citriodora.

LEMON-SCENTED GUM.

Characteristics.—This is a handsome, fast-growing tree, soon becoming tall and slender. In favorable situations in the Southwest it attains a height of 60 to 100 feet in ten to fifteen years. The trunk is straight and even, the foliage being confined mostly to the lofty summit. (Pl. XIV.) Consequently it is necessary to cut it back severely if its leaves and flowers are to be accessible. The bark is light-colored, faintly mottled by indentations that indicate where thin patches have flaked off. This mottling of the trunk, together with the stately character of the tree, the graceful foliage, the profuse bloom, and the fragrant leaves, make this Eucalypt one of the most attractive of the genus. (Pl. XV.)

The stems and leafstalks of the young seedlings are rough, with short, brownish hairs, and their leaves oval or lance-shaped, with the leafstalk attached above the roundish base. (See Pl. LXXXI, D.) The leaves of the tree are long, quite narrow, and equally shiny green on the two sides. The foliage possesses a pleasant odor closely resembling that of a lemon, giving the tree its varietal name *citriodora*, the Latin for "citrus-

odored." The flowers are abundant and conspicuous, in compound clusters. The flower buds are often nearly pear-shaped, the covering being nearly hemispherical. The seed cases are either egg-shaped or somewhat globular. (See Pl. LIII.)

Climatic requirements.—The tree thrives in the frostless coast region, but is not suited to the dry interior valleys. It is especially sensitive to low temperatures. Baron von Mueller says of it, in his Select Extra-tropical Plants, that it is "particularly adapted to a tropical jungle-clime."

Uses.—On account of the characteristics mentioned above this tree is suited for forest planting in the lowlands of tropical and semi-tropical regions. The wood is of a grayish, brownish, or yellowish tint; and flexible, strong, and durable. According to Mr. Maiden the timber is used for fencing, implement handles, shipbuilding, paving, railway ties, bridge building, lumber for inside woodwork of homes, carriage making, and for railway coaches. It is said to be replacing American hickory, in Australia, in coach factories along the coast. The great value of this wood is due to its strength, elasticity, and beauty. It has been especially useful in Australia for paving. In the Southwest, where the good hard-wood timber used is shipped from the Northeast, planters of Eucalypts would do well to consider the merits of this excellent, fast-growing tree. Its profuse bloom makes it valuable also for bee pasture.

Eucalyptus coriacea.

Drooping White Gum.

Characteristics.—The tree is of medium size, rarely exceeding 75 feet in height and 3 feet in diameter. It is a stately and quite handsome tree. The main branches are usually spreading, and the smaller branches drooping. The bark is smooth and grayish. The twigs and flower clusters are sometimes adorned with a bluish white bloom. The leaves are shiny, the same color on both sides, and quite thick, giving the tree its specific name *coriacea*, the Latin for "leathery." The principal veins run lengthwise of the leaf. The medium-sized flowers are in compact clusters. The shape of the fruits is that of the broader part of an egg.

Climatic requirements.—The tree does best in regions of moderate temperatures, a short distance from the coast. It is resistant to frost. In Australia it grows from the base to near the top of the highest mountains. It will not endure drought, nor a dry, hot atmosphere, though supplied with plenty of water artificially. The specimen at the Santa Monica Forestry Station died during the recent drought in the Southwest.

Uses.—The timber is comparatively soft, splits fairly well, but is rather brittle. It is not useful for underground purposes, but makes

a good fuel. Since, according to Baron von Mueller and Mr. Maiden, it extends up the Australian alps nearly to the permanent snow line, it ought to be useful as a forest cover for some of the mountains of the Southwest.

Eucalyptus cornuta.

YATE.

Characteristics.—The tree does not attain a great height, and is often spreading in habit, branching low and profusely. The trunk is likely to be more or less crooked. (See Pl. II A.) The wood is one of the heaviest among Eucalypts. The bark of the trunk is never deeply furrowed, but is commonly more or less uneven, and occasionally nearly smooth. It is usually persistent, but sometimes small patches are shed. The color is a drab. The branches are unusually smooth, from the repeated flaking off of long strips or irregular patches. The twigs are usually quite red or purplish. The foliage is abundant and pleasing in appearance, especially on young trees. The tree as a whole presents a more or less graceful appearance.

The leaves of the young trees are round or oval, becoming longer as the tree increases in age. (See Pl. LXXXII, D.) They are rather thin in texture. The flowers are large and quite conspicuous, in compact clusters, giving, with the foliage and graceful twigs, an attractive aspect to the tree. The deciduous covering of the flower buds is very long and prominent (the characteristic to which reference is made in the specific name *cornuta*, the Latin for "horned"), exposing, when it falls off, the long yellow stamens. (See Pl. LIV.)

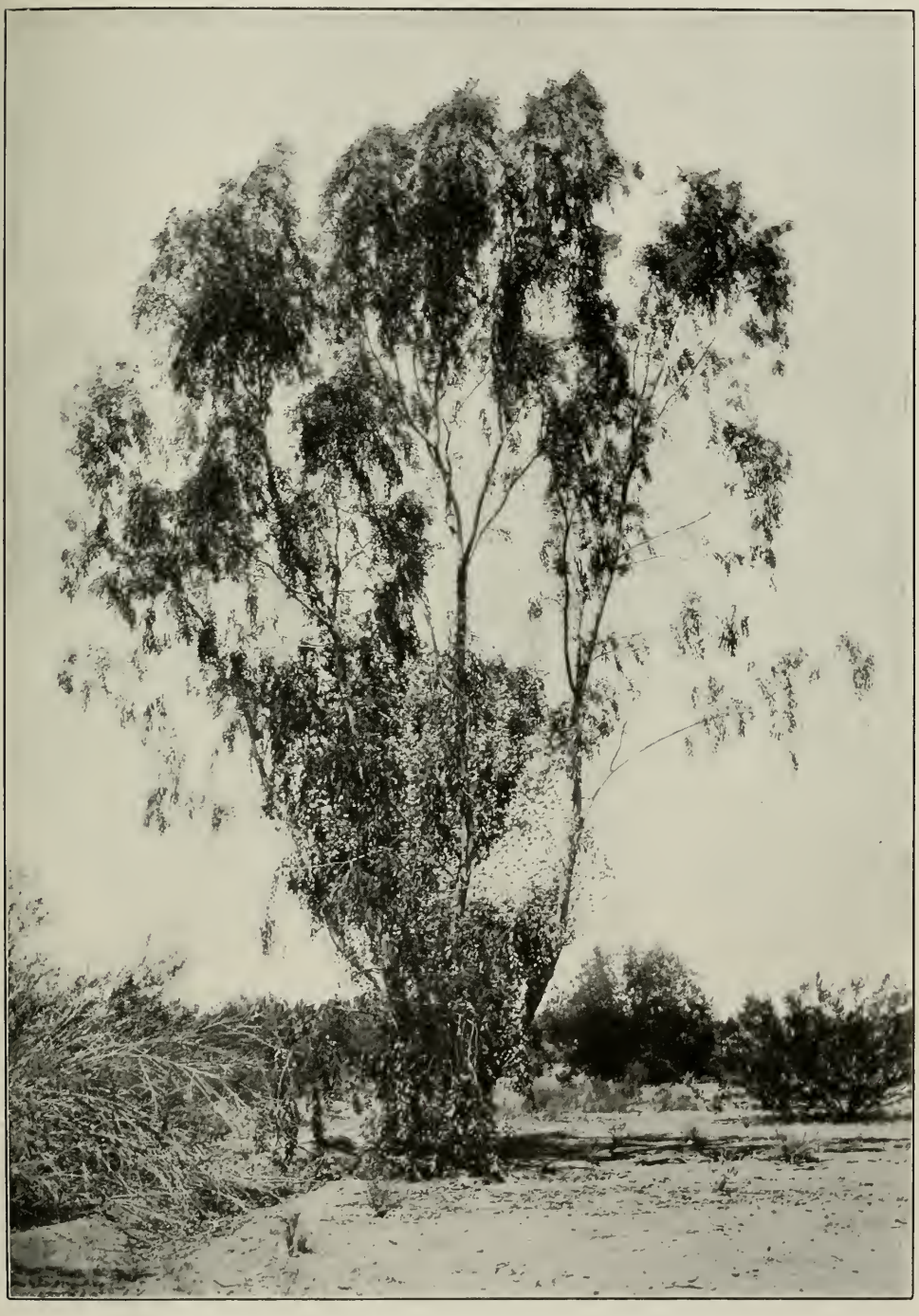
Climatic requirements.—The Yate endures high temperatures, but will not endure heavy frosts. It thrives on the coast, and endures the dry hot summers of the interior valleys of California and Arizona, provided its roots are supplied with plenty of water. It endures temperatures of 110° to 116° F., but is injured by minimum temperatures of 23° to 26° F. It prefers a rich, moist soil, but will make a fair growth in poor soil. It seems to be well adapted to moist tropical and semitropical regions, enduring more rain than many other Eucalypts.

Uses.—On account of its manner of growth and the density of its foliage the Yate makes a very effective, low wind-break and a good shade tree, few Eucalypts branching freely so low as it does. The wood is hard, tough, and elastic, being used in Australia for agricultural implements, for vehicles, and for boat ribs. In California it has been used almost wholly as a shade tree.

Eucalyptus corymbosa.

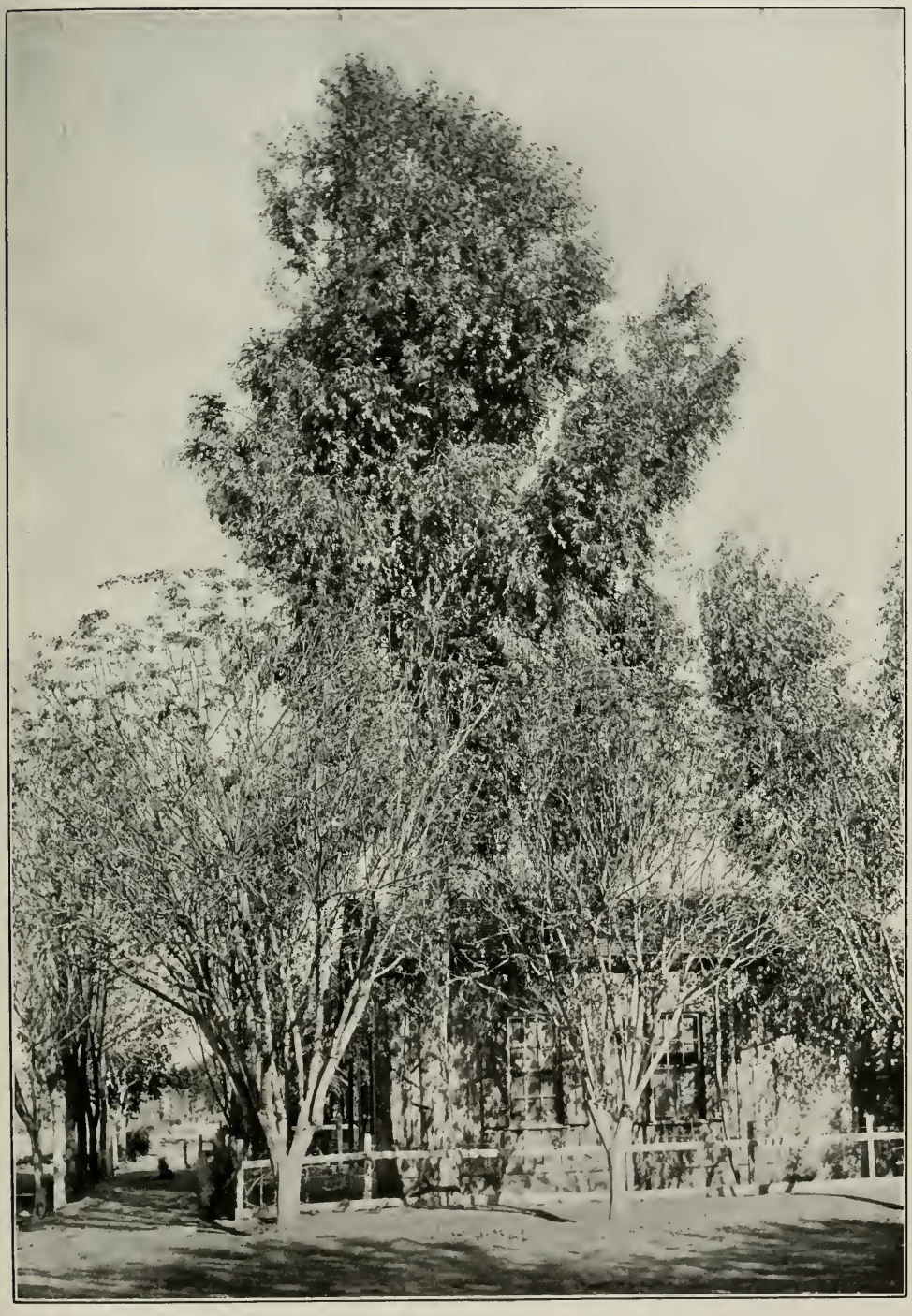
BLOODWOOD.

Characteristics.—The Bloodwood is a tree of moderate size, reported from Australia as sometimes being stunted and somewhat shrubby in



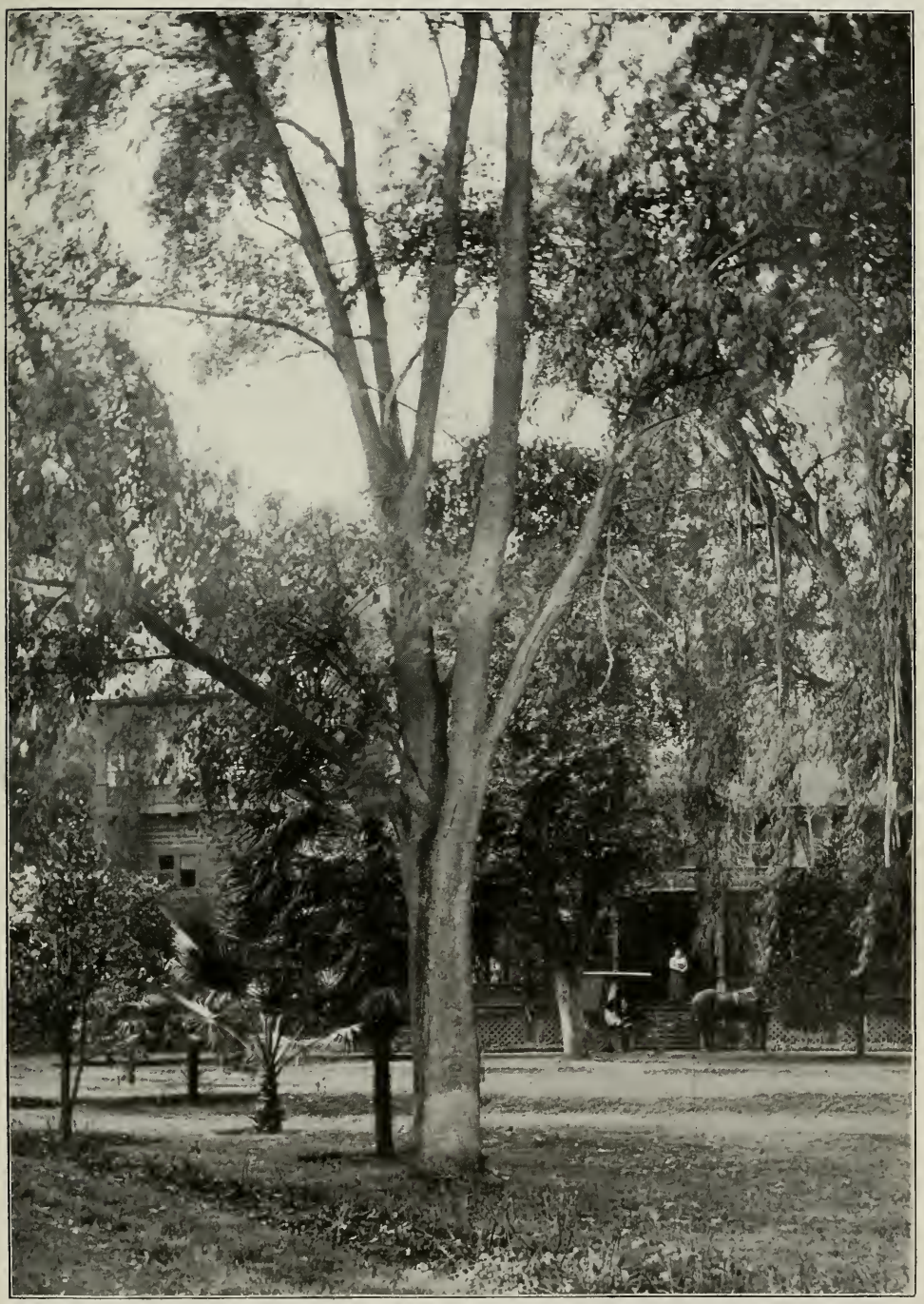
EUCALYPTUS ROSTRATA (RED GUM) NEAR GLENDALE, ARIZ.

Tree 12 years old, not having been irrigated for six years. Diameter of trunk at base, 18 inches.



EUCALYPTUS ROSTRATA (RED GUM), PHOENIX, ARIZ.

Tree 8 years old, grown by irrigation. Diameter of trunk, 20 inches.



EUCALYPTUS RUDIS ON GROUNDS OF MINNEWAWA RANCH, FRESNO, CAL.

Tree 12 years old. Diameter of trunk, 2 feet. This species endures more heat and severer frosts than any tree in the Southwest.

EUCALYPTUS RUDIS, ON MINNEWAWA RANCH, FRESNO, CAL.

Trees 12 years old. Diameter of trunks, 15 to 30 inches.

appearance, but frequently attaining a height there of over 100 feet and a diameter of 3 feet. The grayish or brownish bark of the entire trunk is commonly rough, wrinkled, and persistent; that of the upper branches smooth and cream-colored or reddish. (Pl. XVI.)

The leaves are somewhat leathery, varying in shape from oval to slender lance-shaped. They are paler beneath and frequently mottled yellowish and green or red. The veins are numerous and spread like the parts of a feather, giving the leaves quite a characteristic appearance. The young leaves when torn asunder show the presence of a rubber-like fluid by the fine glutinous threads that are drawn out. The bloom is very profuse from an early age. The flowers are white or creamy in color, above the average in size, in rather open, flat-topped clusters. They contain a large amount of nectar and are consequently much visited by bees. The large seed cases are urn-shaped or somewhat egg-shaped, on slender, slightly flattened stems, quite different in appearance from those of any other Eucalypts. The seedlings develop at an early age leaves similar to those of the adult tree. (See Pl. LV; Pl. LXXXI, B.)

Climatic requirements.—Comparatively little is known of the parts of America to which Bloodwood is adapted. It does well near the coast, but does not thrive in the dry, hot interior valleys. Judging from its habitat in Australia, it can not be expected to grow thriftily far in the interior, nor where heavy frosts occur.

Uses.—This tree furnishes a wood that is quite easily worked when fresh, but the wood when dry is very hard. It is very durable underground and is said to be resistant to white ants, this quality being due to the large amount of kino it contains. Fence posts of it are reported to have lasted forty years in Australia. Mr. Maiden says of the timber: "For posts in the ground, and for use in culverts, it is all but imperishable." The presence of kino renders the timber unsuitable for lumber, and causes it to make poor fuel, but renders it more valuable for paving, for posts, and for other uses in underground situations. It is one of the sources of the kino of commerce.

Eucalyptus corynocalyx.

SUGAR GUM.

Characteristics.—The tree attains a fair size and is commonly symmetrical and erect. (Pl. XVII.) Its growth is quite rapid from an early age. The usual height is 50 to 100 feet, and in Australia the trunk is said to often attain a diameter of 5 or 6 feet. As a rule the trunk is straight with only a slight taper. The bark is left smooth by the continuous flaking off of patches or strips. The bark of the main stem is usually a deep cream color, that of the branches darker before shedding, and of the young twigs quite red.

On young trees the leaves are mostly round or oval, while those of the mature trees are nearly lance-shaped. (See Pl. LXXXI, c.) The latter are somewhat thick, the upper surface being a shiny dark green and the lower surface dull and lighter in color. The bloom is profuse from an early age, and the flowers are conspicuous among the leaves. During the blooming season the trees are visited by large numbers of bees. It produces flowers during several months, the autumn being the time of the year when bees frequent it most. The unopened buds are club-shaped and the cover abruptly pointed. The fruit is oblong, urn-shaped, with longitudinal streaks or faint grooves showing on the face of some specimens. (See Pl. LVI.)

Climatic requirements.—The Sugar Gum will grow in a variety of climates. It thrives in California within a few hundred yards of the water of the Pacific Ocean, and grows equally well in parts of the dry valleys of southern Arizona. It profits by moisture, but will endure a great amount of drought. In the interior valleys of southern California and Arizona it withstands both the intense heat of summer and the frosts of most winters, enduring a maximum temperature of 110° to 115° F., and a minimum temperature of 20° to 25° F. As illustrations of its adaptability to different environments, fine specimens of these trees can be seen at Santa Monica, Cal., and near Glendale, Ariz.

Uses.—The Sugar Gum can be used as a forest cover in hot, arid regions where the frosts are not too severe. Baron von Mueller says: "For desert country this is one of the most eligible among timber Eucalypts," using the term "timber Eucalypts" in distinction from the smaller species (called in Australia "mallee shrubs") that thrive in hot, desert regions. Among those attaining the stature of trees the Sugar Gum is one of the best for forest culture in a desert region. It must be understood, however, that it does not endure the heaviest frosts that occur in winter in some parts of the arid Southwest having hot summers, nor the high temperatures of some of the hottest valleys. Thus far it has been used in California chiefly as an avenue shade tree, its value as a forest and timber tree not having been realized by many. To be sure it is a useful species for furnishing shelter and shade to stock in desert regions, but its greater usefulness lies in other directions. The Sugar Gum deserves to be planted much more generally and upon a much larger scale than it has been, it being one of the most generally useful species of the genus. It does not grow quite as rapidly as the Blue Gum, but is more useful for many purposes. As a source of fence posts it is very valuable.

The Sugar Gum furnishes a timber that is very durable as railway ties, as posts, and for other underground situations. Baron von Mueller states that posts set in the ground fifteen years showed no signs of decay. The wood warps very little in drying, and when dry is very hard. It is also useful for the naves and felloes of wheels.

Eucalyptus crebra.

NARROW-LEAVED IRON-BARK.

Characteristics.—This iron-bark is usually a slender tree of pleasing aspect, growing about 100 feet high and 2 to 3 feet in diameter (Pl. XVIII). The trunk is commonly straight and even in size. According to Maiden, Sir William Macarthur pronounced it: "The most picturesque of the different species of Eucalypts called iron-bark." The bark, like that of other iron-barks, is rough and persistent. It is harder, darker, and more deeply furrowed than the bark of either *Eucalyptus paniculata* or *Eucalyptus siderophloia*, approaching closely to *Eucalyptus sideroxylon* in these respects. The wood is reddish, with inlocked fibers. The branchlets are slender and drooping, presenting with the foliage a pleasing appearance.

The leaves are narrow, equally green on the two surfaces, and quite thin; veins and oil dots not conspicuous. The flowers are very small, in clusters of 3 to 7, usually occurring in panicles. The seed cases are very small, goblet-shaped or cup-shaped, with minute valves. (Pl. LVII.)

Climatic requirements.—The narrow-leaved iron-bark endures a greater variety of climatic conditions than do the other iron-barks. It is the only one of the group that will endure the climate of the dry, hot interior valleys of the Southwest. At Fresno, Cal., it grows vigorously, and young trees have grown well at the Experiment Station farm near Phoenix, Ariz. It endures minimum temperatures of 18° to 20° and maximum temperatures of 110° to 118°. It is said to be content with poor soil. Judging by experience with the species thus far, it ought to grow in most valley and hillside situations in the Southwest.

Uses.—Upon account of the wood being so hard, tough, and elastic, the timber is useful for a great variety of purposes. It is one of the highly valued timber trees of Australia. The wood is durable under ground, and is consequently much used for posts, railway ties, and piles. It is also useful for bridge material, for wagon making, and for a great variety of technic purposes.

Eucalyptus diversicolor.

KARRI.

Characteristics.—The Karri is a large and stately tree, in the Southwest growing much more rapidly than *Eucalyptus amygdalina*, the only tree that in Australia exceeds it in height. Baron von Mueller pronounces it one of the grandest trees of the globe and "one of the greatest wonders in the whole creation of plants!" He states that he has seen trees of this species nearly 400 feet high, and that trees with

a basal diameter of 20 feet have been seen. The trunks are usually straight and even, and the grayish bark usually smooth. The latter is commonly persistent, but occasionally irregular pieces flake off. (Pl. XIX.)

The foliage is attractive in appearance, the leaves of the young seedlings being oval or roundish (See Pl. LXXXIII, B), and those of the adult tree narrower. They are dark green above and paler beneath, the latter characteristic, although possessed in common with several other Eucalypts, giving cause for its specific name *diversicolor*. The flowers grow in clusters of 4 to 8, with rather slender, somewhat flattened stalks. The seed cases are egg-shaped or goblet-shaped. (See Pl. LVIII.)

Climatic requirements.—This species thrives in moderately moist situations near the coast, but does not endure well the dry heat of the interior. It is said to be quite resistant to frost. The best specimens observed by the writer grow between Los Angeles and Pasadena, Cal., where the atmosphere is moderately humid and the frosts light.

Uses.—In situations favorable for its culture the Karri may be grown for a forest cover as a rival to the Blue Gum. Its growth is fairly rapid, and its timber is superior to that of Blue Gum for some purposes. The wood is straight-grained and is used in Australia for lumber (for which it is especially valuable), for wheelwright work, and for shipbuilding. The tall, straight trunks make good masts.

Eucalyptus eugenioides.

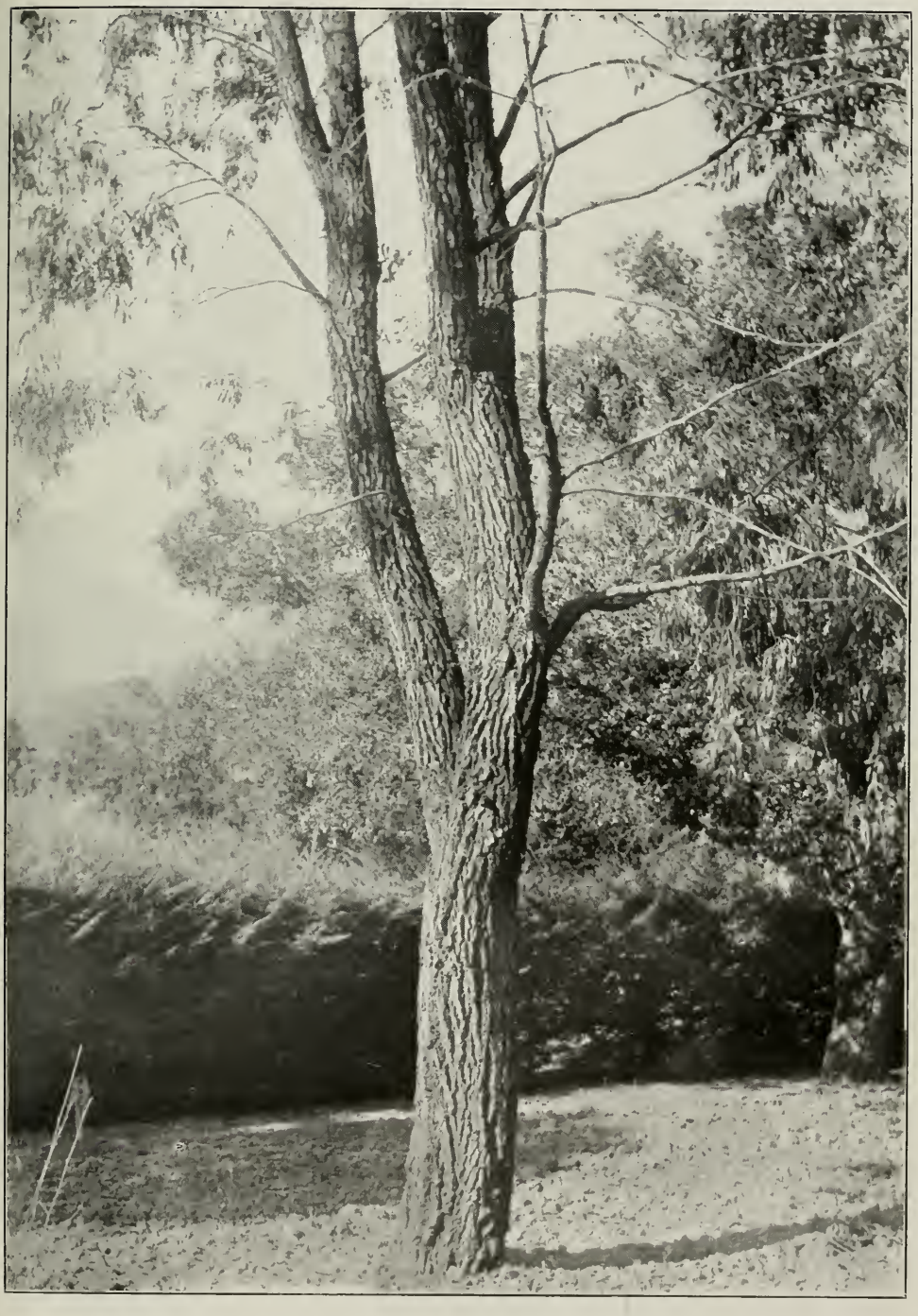
White Stringy-bark.

Characteristics.—Under favorable conditions this tree attains a good size, reaching in Australia a height of 150 to 200 feet even in sandy soil. It is a shapely tree when young, presenting a pleasing appearance. The bark is rough and persistent, the outer surface being soft and stringy. The fibers of the bark possess, in common with those of other "Stringy-barks," considerable tenacity. The bark as a whole resembles considerably that of American cedars, the color being a mixture of dark gray and tan. (Pl. XX.)

The young seedlings are clothed with soft hairs, and the leaves are opposite and notched. Later the twigs become smooth and the leaves regular in outline, the latter being ovate or lance-shaped, often with unequal sides, with the two surfaces of the leaves nearly equally green. The foliage is quite dense. The flowers are of medium size, in compact clusters. The seed vessels are cup-shaped. (See Pl. LIX.)

Climatic requirements.—This Stringy-bark is best adapted to a moderately humid region with a climate not too hot. It does fairly well near the coast of California, but does not endure the dry heat of the interior valleys.

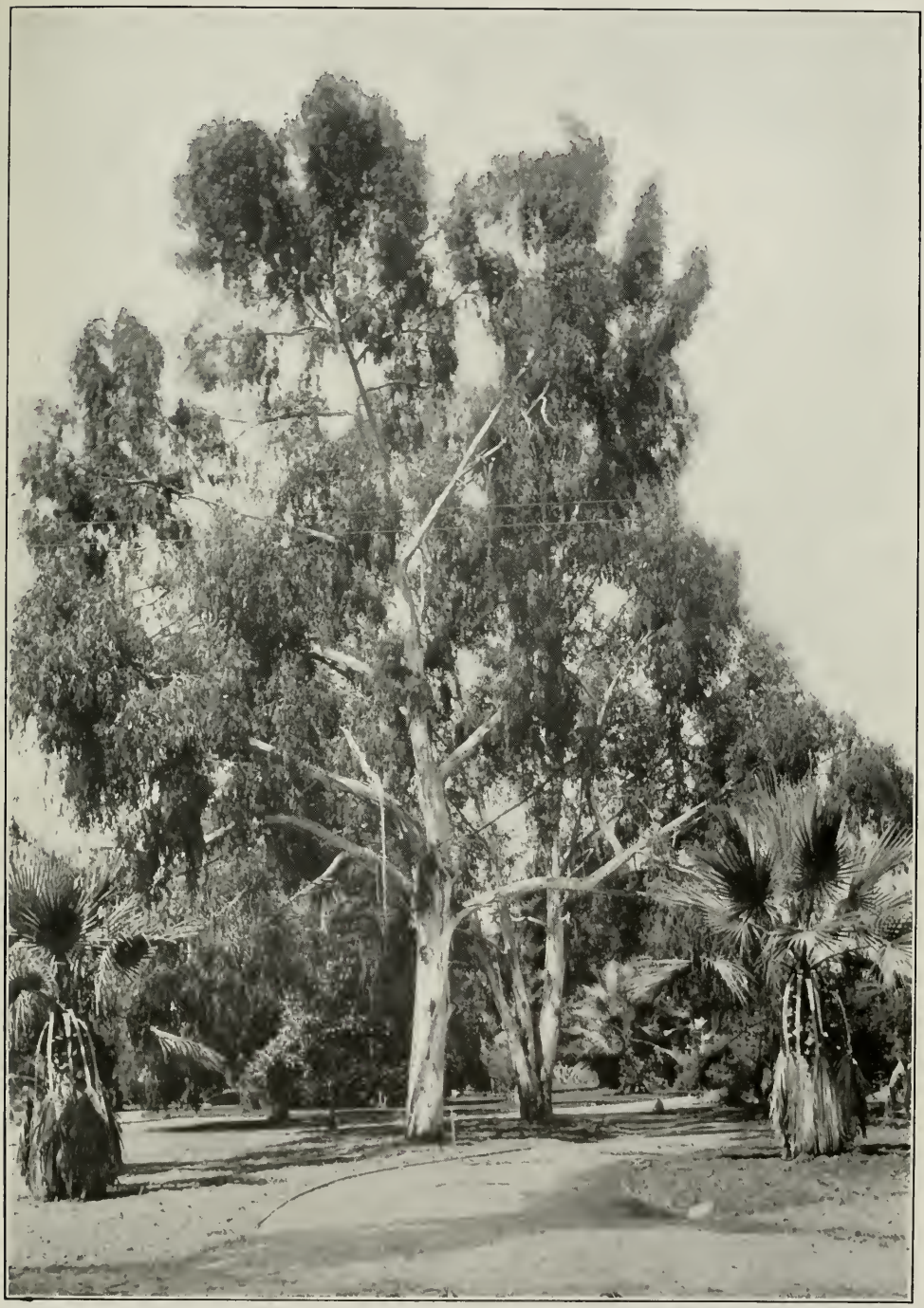
EUCALYPTUS SIDEROPHLOIA. TREES 8 YEARS OLD. EAST LAKE PARK, LOS ANGELES, CAL.



EUCALYPTUS SIDEROXYLON, MONTECITO, CAL.

EUCALYPTUS VIMINALIS, PASADENA, CAL.

Tree 24 years old. Diameter of trunk, over 5 feet.



EUCALYPTUS VIMINALIS, SOUTH PASADENA, CAL. TREES 12 YEARS OLD.

Uses.—The timber is strong and durable, splits readily, and is not liable to warp. It is useful for lumber, for fence rails, and for posts. The bark is used for roofing, for mats, and for strings. The leaves are a source of Eucalyptus oil.

Eucalyptus globulus.

BLUE GUM.

Characteristics.—This species is the best known of the Eucalypts and in many respects the best known tree in all the world. Baron von Mueller says of it: "Of the more than 1,000 different species of trees indigenous to Australia, *Eucalyptus globulus* takes the first position in importance, and among its own kind it is the prince of Eucalypts." It is the third tallest of the species of Eucalyptus, the usual height in Australia being 200 to 300 feet. In California, where trees can be found 30 or more years old, many have attained the height of 150 feet, and a diameter of 3 to 6 feet during these years. One tree in Pasadena, 25 years old, is over 5 feet in diameter. Trees set thirty years ago along an avenue in Santa Barbara range from 3 to 5 feet in diameter. (Pl. XXI.) There are many instances of these trees attaining the height of 50 or 75 feet in from five to ten years. It is without doubt the fastest growing tree in the world. It is friendly to new conditions, and, taking all its characteristics into consideration, it is the best all-round Eucalypt. It has been more extensively planted throughout the world than any other Eucalypt and probably more extensively than all other Eucalypts combined. The tree varies as to its habit of growth, but is usually quite erect, though not always symmetrical in form. By a continual flaking off of its bark in patches or long strips it is left smooth and greenish or grayish in color. Occasionally, however, trees are seen with the bark persistent, especially near or at the base. (Pl. IV, A.)

The leaves of the young seedling and of sprouts from the tree are quite different from those of the adult trees. The earlier leaves have a dusty, light-bluish coat, and are broad and opposite on the stems (see Pl. LXXXIII, C), while those of the adult are smooth and elongated. The young twigs are four-sided, while those on the adult trees are cylindrical, or nearly so. The flowers are large and quite conspicuous. They grow singly or in clusters of 1 to 3. A prominent characteristic of the flower bud is its rough, warty protuberances. The seed cases are large and nearly hemispherical in form. (See Pl. LX.) The seeds are larger than those of most of the species.

Climatic requirements.—This remarkable tree has the power of adapting itself to a variety of climatic conditions. It thrives both in moist, warm regions and in quite hot, dry ones. It makes a good growth both in lowlands and in dry, stony uplands. Its powers of removing stagnant water from low situations and of maintaining a

thriftiness in dry situations and during droughts are remarkable. In many situations in the Southwest, where, during the three years 1897 to 1900, the annual rainfall was from 4 to 8 inches only, the Blue Gum, in most cases, maintained a thrifty growth.

These trees are resistant to both quite high and quite low temperatures. While the young trees will not usually endure a continued temperature much below 27° F., they will endure maximum temperatures of 100° to 105° F., if the air is not especially arid; they do not, however, endure maximum temperatures much above 105° F. in the dry interior valleys of southern California and southern Arizona. In southern Arizona they endure minimum temperatures of 18° F., but are severely injured by the dry winds of summer when the mercury is above 103° to 105° F. Several species of Eucalypts endure both lower and higher temperatures than these, but there are few species that do so well when subjected to extremes.

Uses.—This species is the most generally useful of all the Eucalypts. It is especially useful as a forest cover. Being adapted to such a variety of soil and climatic conditions it can be used to cover a great variety of lands Baron von Mueller says:

> For mitigating the heat of the arid treeless regions, subject to high summer temperature, *Eucalyptus globulus* plays a most important part also. But the culture of the tree should be *million fold.* * * * The rearing of forests of our Blue Gum tree can be accomplished more cheaply and more easily than that of almost any other tree, while the return is twice or three times earlier than that of the most productive Pine or Oak forests, and this raising of Eucalyptus forests can be extended to regions in which most Pines and all Oaks would cope in vain with an almost rainless clime, although Eucalyptus culture can never advance to cold zones. * * * Sterile land, unless it be absolute sand, will soon be transformed into a verdant and salubrious grove, more particularly so if substrata do not consist of impenetrable layers or outcrops of rocks. While quietly the forest advances, almost without expenditure and care, its wood treasures increase from year to year without taxing the patience of generations, and within less than half the lifetime of man timber of conspicuous dimensions can be removed after fuel has been provided annually long before, while the unpropitious original surface-soil will have been converted into a stratum of fertility for agricultural or pastoral returns from successive storage of mineral aliments brought up.

In the Southwest this species has proved to be the most useful one to plant for wind-breaks and for shade. It is also the one that has been planted most extensively for fuel and for timber. (Pl. XXIII.) It has been used for piles in several wharves on the Pacific coast with very satisfactory results. It is also the one that is used principally as the source of eucalyptus oil in California.

The timber of this tree is of a rather pale color, is hard, heavy, and very strong and durable. It is fairly straight-grained and quite easily split. In Australia it is used for shipbuilding, for carriage making, and in the manufacture of agricultural implements. It is also used in bridge building, for telegraph poles, and for railway ties. In Cali-

fornia the wood is being extensively and successfully used for insulator pins. It is also being used with success in the manufacture of parts of agricultural implements (harvesters, etc.) and the handles of plumbers' and carpenters' tools, for which purposes it is considered almost, if not quite, equal to hickory.

Eucalyptus gomphocephala.

TOOART.

Characteristics.—The tree is rather stocky and is usually symmetrical. At Mr. Ellwood Cooper's ranch it has attained a height of 80 feet in twenty-four years. (Pl. XXIV.) The bark of the trunk is dark gray, rough, and persistent. From the branches the bark flakes off in strips, leaving the surface smooth and light-colored. The twigs are reddish yellow. The leaves are thick and shining and somewhat leathery, the upper surface being darker than the lower. The flowers are of large size. The stalk of the flower clusters is flattened, the flowers themselves being stemless. The hemispheric lid of the unopened bud is broader than the part below, giving the buds the appearance of pegs, the specific name *gomphocephala* being the Greek for "peg-head." The seed cases are top-shaped, bell-shaped, or hemispherical, and are one-half to three-fourths of an inch broad. (See Pl. LXI.)

Climatic requirements.—The Tooart thrives along the coast and does fairly well in the dry interior valleys. It has not been grown extensively enough yet to determine definitely what degrees of heat and cold it will endure in America.

Uses.—The tree furnishes a heavy wood that is very tough and strong—one of the strongest timbers in the world. The grain is so close and curled or twisted that it is not easily split. The timber is used principally in shipbuilding and for bridges. It is very durable in all kinds of weather and in a great variety of situations.

Eucalyptus goniocalyx.

Characteristics.—This tree commonly attains a good size, in some situations in Australia reaching a height of 300 feet, with a diameter of 6 to 10 feet. At Mr. Cooper's ranch the trees in a grove twenty years old range from 8 to 18 inches in diameter. (Pl. XXV, A.) The bark is commonly persistent, but in some cases flakes off; the character of its surface also varies.

On the young tree, and on sprouts from the trunk, the leaves are opposite, heart-shaped or kidney-shaped, and broadly oval. (See Pl. LXXXIV, B.) The leaves of the adult trees are long and quite slender, the two sides being similarly colored. The flowers are nearly stemless, in small clusters borne on flattened stalks. The seed cases are nearly cup-shaped, and are usually more or less angled. (See Pl. LXII.)

Climatic requirements.—This species grows well in the coast regions of California, but, so far as known, it has not been tested in the dry, hot valleys of the interior, or other similar situations. In Australia it ascends to an elevation of 4,000 feet, and is therefore a promising species for the mountains of the Southwest.

Uses.—The tree furnishes a hard, tough wood used by wheelwrights, by boat builders, and for general building purposes. It is very durable in the ground and is consequently useful for railroad ties, for posts, and for other purposes in underground situations. It also makes an excellent fuel.

Eucalyptus gunnii.

CIDER EUCALYPT.

Characteristics.—The tree is usually not a tall one, but in some situations in Australia it is said to rise to a height of 250 feet. No trees growing in the Southwest, however, give promise of attaining a great height, though some of them are already 60 feet high. The trees are sometimes crooked and irregular in growth. In alpine regions they are said to be mere shrubs. The bark of the trunk is usually rough and brownish, and is continually flaking off, leaving the outer part smooth. The branches are usually smoother. The foliage is denser and darker than that of many Eucalypts, frequently being confined to the ends of the branches, however. The leaves of the young trees are roundish, and opposite on the stem (see Pl. LXXXIV, D.), and those of the adult tree are scattered and lance-shaped. They are usually shiny and more or less stiff. The flowers are of medium size and the seed cases usually nearly top-shaped. (See Pl. LXIII.)

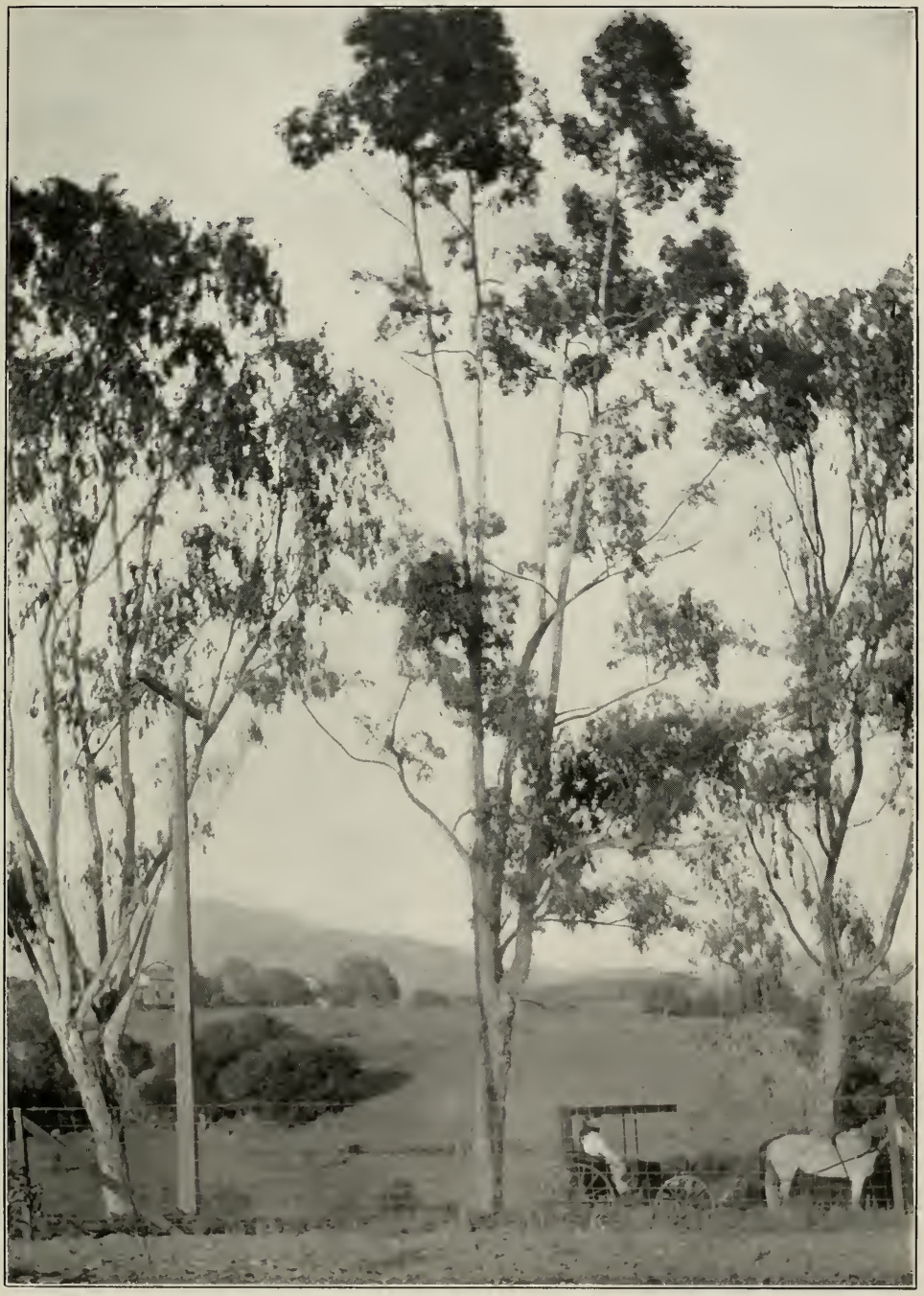
Climatic requirements.—This species grows well near the coast and for some distance inland. It is a very hardy species, and, since in Australia it grows to an elevation of 4,000 to 5,000 feet, it ought to succeed in elevated regions of the Southwest. It endures fairly well the summer heat of the interior valleys, and during winter grows thriftily, even though the temperature fall to 20° F. each night.

Uses.—The tree does not furnish an especially useful timber. When it grows straight it is used by artisans for many purposes, and it also makes a fair fuel. It is a very promising species as a forest cover for mountain situations not subject to high summer temperatures. The sap of the alpine form of the tree is said to be used by the aborigines of Australia for making a kind of cider.

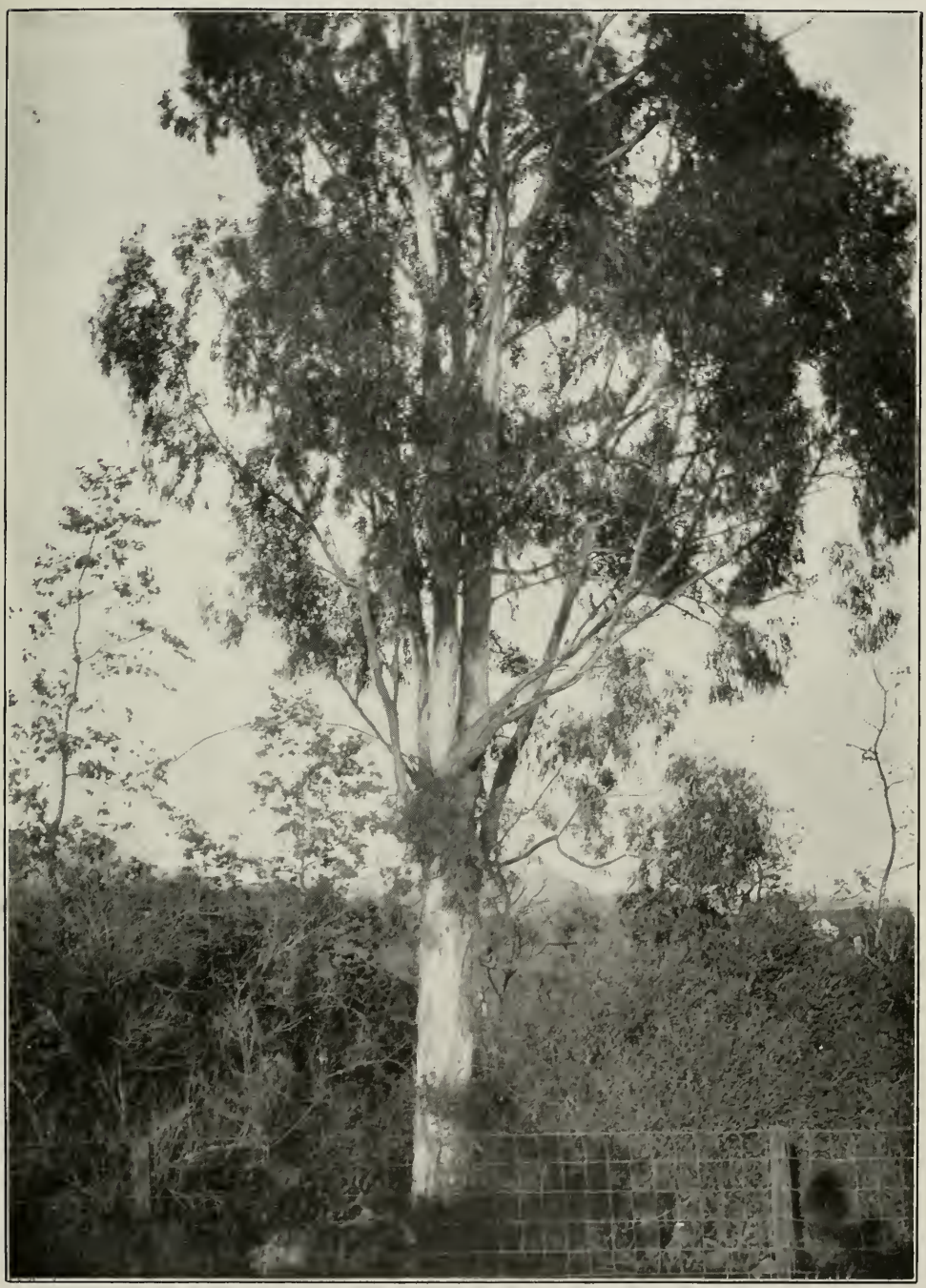
Eucalyptus hæmastoma.

WHITE GUM.

Characteristics.—This is a tree of medium size, being usually erect and symmetrical in form. The bark is commonly smooth, but is sometimes rough and persistent. The leaves are thick, usually lance-shaped



EUCALYPTUS VIMINALIS, MONTECITO, CAL. TREES 20 YEARS OLD.



EUCALYPTUS VIMINALIS, MONTECITO, CAL. TREES 20 YEARS OLD, GROWING AMONG NATIVE SHRUBS AND TREES.

EUCALYPTUS AMYGDALINA.

EUCALYPTUS BOTRYOIDES.

EUCALYPTUS CALOPHYLLA.

EUCALYPTUS CITRIODORA.

EUCALYPTUS CORNUTA.

or sickle-shaped, but occasionally verging into a somewhat oval form. (See Pl. LXXXV, B.) They are shiny green on the two sides. The flowers are of medium size, in clusters of 5 to 7, on somewhat angular, flattened stalks. The covering of the flower buds is rounded, with an abrupt point. The fruits are cup-shaped or goblet-shaped, with brownish or reddish rims. The latter characteristic gives the tree its specific name *hæmastoma*, meaning "bloody mouth."

Climatic requirements.—This tree thrives near the coast, but is not suited in the dry interior valleys. It is said to thrive on sandy soil.

Uses.—Von Mueller and Maiden state that the wood is not of any great value for timber or fuel, but furnishes the material for fencing and for rough carpentering. It has not yet been grown extensively enough in America to determine its qualities and uses.

Eucalyptus hemiphloia.

GRAY BOX.

Characteristics.—The individuals of this species attain a fair size, the usual height in Australia being 75 to 150 feet, with a trunk diameter of 1 to 4 feet. At Cooper's ranch, Santa Barbara, it has attained a height of 80 feet and a diameter of 18 inches in twenty years. (Pl. XXVII.) The bark of the trunk is persistent and rough, but never deeply furrowed. It is usually of a grayish color. The bark of the branches commonly flakes off in long strips, leaving them smooth. The leaves are of a somewhat thick texture, varying in shape from oval to lance-shaped. They are dark green on the two sides, giving to the tree a deep green, pleasing aspect. The flowers are of medium size, in clusters of 4 to 10, on stalks that are sometimes angular. The covering of the flower buds is sharply pointed. The fruits are commonly nearly goblet-shaped. (See Pl. LXIV.)

Climatic requirements.—This Eucalypt thrives at and near the coast, on the interior foothills, and in the hot, dry valleys of the interior. It grows equally well at Pasadena, Cal., and at Phoenix, Ariz. It will endure minimum temperatures of 15° to 20°, and maximum temperatures of 110° to 115°, never having been injured in the slightest by the heaviest frosts or the hottest winds of the dry interior valleys of Arizona.

Uses.—The foliage of this tree being somewhat more dense than that of many others, it is quite useful as a shade tree. The tree furnishes a timber that is strong, hard, and close, but not easily split. The wood is used in Australia for wheelwright's work, for mauls, for handles of various implements, and for various purposes for which a tough, hard wood is used. It is very durable underground, and is consequently useful for piles, for ties, for fence posts, and for other similar objects. Baron von Mueller states that posts of this wood, after

being sixteen years in use, were found almost perfectly sound in the ground. Maiden states that it is one of the best fuel woods they have in New South Wales.

Eucalyptus leucoxylon.

SOUTH AUSTRALIAN BLUE GUM.

Characteristics.—Trees of this species attain fair size in a comparatively short time and when full grown are large. They are apt to grow out of the perpendicular and the trunks are frequently crooked. By giving them some attention when young, however, they may be made to grow erect and straight. The bark is smooth and light in color. (Pl. XXVIII.) The wood is white and quite straight grained, the former characteristic giving to the tree its specific name *leucoxylon*, the Greek for "white wood." The foliage has a pleasing bluish cast, and is well distributed over the tree. The leaves of the young seedling are broad, opposite, and stemless or short stemmed. (See Pl. LXXXVI, A.) The seedling is weak and disposed to recline on the ground in a vine-like manner. Later it assumes an approximately erect position. The leaves grow scattered and are long and slender on distinct stems, the whole aspect of the tree being quite different from that of the seedling. The flowers grow in threes on somewhat slender stems and are abundant and quite showy, varying in color from white to pink or reddish. The seed cases are somewhat egg-shaped or globular. (See Pl. LXV.)

Climatic requirements.—This tree will grow in a greater variety of climates than most Eucalypts. In fact, there are few situations in the Southwest in which it will not thrive. It grows vigorously on the coast, on the interior plains and foothills, and in the dry, hot desert valleys of the interior. It is especially thrifty at Santa Monica (Pl. XXVIII), within a few rods of the ocean, and at Phoenix, Ariz. (Pl. XXIX). It endures minimum temperatures of 15° to 20° F. In fact, the writer has never observed it seriously injured by the heaviest frosts nor the highest temperatures that occur in the desert regions of Arizona. It is one of the hardiest of the fast-growing forest trees from Australia.

Uses.—On account of its adaptability to so great a variety of climatic conditions, it can be used as a forest cover for almost all kinds of situations, and thus supply a timber useful for a large number of purposes. It can be grown for fuel and for the other purposes that the ordinary Blue Gum (*Eucalyptus globulus*) serves where the latter will not grow.

Eucalyptus longifolia.

WOOLLY-BUTT.

Characteristics.—The tree is usually shapely, and commonly attains only a moderate size, but sometimes reaches a height of 200 feet in

Australia. The trunk is straight, and its grayish, tan-colored bark is rough and persistent. (Pl. XXX.) The bark of the branches flakes off, leaving them smooth. The twigs are red or yellowish. The leaves are long (hence the specific name *longifolia*) and sickle-shaped, the two surfaces being equally green. The bloom is abundant, and is present on the tree several months of the year. The seed cases are bell-shaped and somewhat angular, usually growing in threes. They are about one-half an inch long.

Climatic requirements.—The Woolly Butt thrives near the coast, but does not endure the dry heat of some of the interior valleys.

Uses.—The timber is durable, but is not so strong and elastic as that of many of the Eucalypts. It is used for posts, for ties, for street paving, and for quite a variety of similar purposes. On account of the profuse bloom it furnishes nectar for bees, often at a time of the year when other sources are wanting.

Eucalyptus macrorhyncha.

VICTORIA STRINGY-BARK.

Characteristics.—This tree is said to attain a fair height in Australia, but the specimens growing in the Southwest do not yet give promise of attaining great size, due probably to being planted at too low an elevation. The tree has not proved to be a very symmetrical one. The bark of the trunk and branches is thick, fibrous, and persistent, usually a dark-gray color. The leaves of the young seedlings are broad and oppositely placed, the young growth being covered with short, stiff hair. The leaves of the older trees are thick and leathery, being commonly lance-shaped or somewhat sickle-shaped. The flowers are about medium size, on slender stalks, in clusters of 4 to 10. The covers of the flower buds are quite distinctly conical or long-pointed. The seed cases when fully matured are nearly spherical, with a prominent rim and protruding valves. (See Pl. LXVI.)

Climatic requirements.—This species thrives at the coast, and is said to grow in Australia on comparatively sterile mountain ranges. It is in Australia essentially a mountain species, seldom growing on the plains. It will not endure dry, hot climates.

Uses.—The bark of the tree being rough and fibrous, it is used extensively in Australia for roofing sheds, stables, and other outbuildings. Baron von Mueller states that for these purposes it will last for about twenty years. The fibers are also sometimes used for strings. The tree furnishes a wood that is hard and durable and easily split. It is useful for lumber, for fencing, and for shingles and fuel. The tree is a promising one for a forest cover for mountain ranges of the Southwest.

Eucalyptus marginata.

JARRAH.

Characteristics.—Under favorable conditions this tree grows to a large size, being commonly straight and quite slender. Few American specimens are over 30 feet high, however. The average height in Australia is said to be 100 feet, and it sometimes reaches a diameter of 10 to 15 feet there. The bark of the trunk is commonly persistent and somewhat fibrous, but sometimes flakes off in strips. The leaves vary from ovate to lance-shaped, usually somewhat curved. They vary from thin to leathery in consistence. The flowers are quite large, in clusters of 3 to 12, on conspicuous, somewhat flattened stalks. The covering to the flower bud is long and tapering. The seed cases are globular or egg-shaped, being from one-half to three-fourths of an inch long.

Climatic requirements.—In California the Jarrah does not thrive at or near the coast. In interior valleys having moderate aridity and heat it does some better, but at no point in America where it has been set does it grow with sufficient rapidity and vigor to warrant planting it for commercial purposes.

Uses.—In Australia and India the tree is prized for piles and ties. It has the reputation of being unaffected by marine boring animals and white ants. This characteristic has been thought to be due to the presence of a high percentage of kino—15 to 17 per cent—but is now considered attributable to an acid principle contained in the wood. It is also very durable under ground.

Eucalyptus melliodora.

YELLOW BOX.

Characteristics.—The trees of this species are commonly of medium size and spreading habit, but are said occasionally to attain in Australia a height of 250 feet and a diameter of 6 to 8 feet. The trunks are commonly crooked and gnarled, the outer bark of the trunk being of a brownish-gray color and commonly persistent. (Pl. XXXI.) The inner bark is yellow, giving to the tree the name of "Yellow Box." The branches are usually quite smooth. The leaves of the young tree are often oval or oblong (Pl. LXXXVII, A), but the prevailing shape after a few years is lance or sickle shaped, both sides being of a dull-green color. The flowers are of medium size and grow in compact clusters with short stems. They emit a pleasant, honey-scented fragrance, a characteristic to which the name *melliodora* (the Latin for "honey odor") refers. The seed cases are nearly the shape of an egg with the small end cut away. (See Pl. LXVII.)

Climatic requirements.—This species will grow near the coast, on

EUCALYPTUS CORYMBOSA.

EUCALYPTUS CORYNOCALYX.

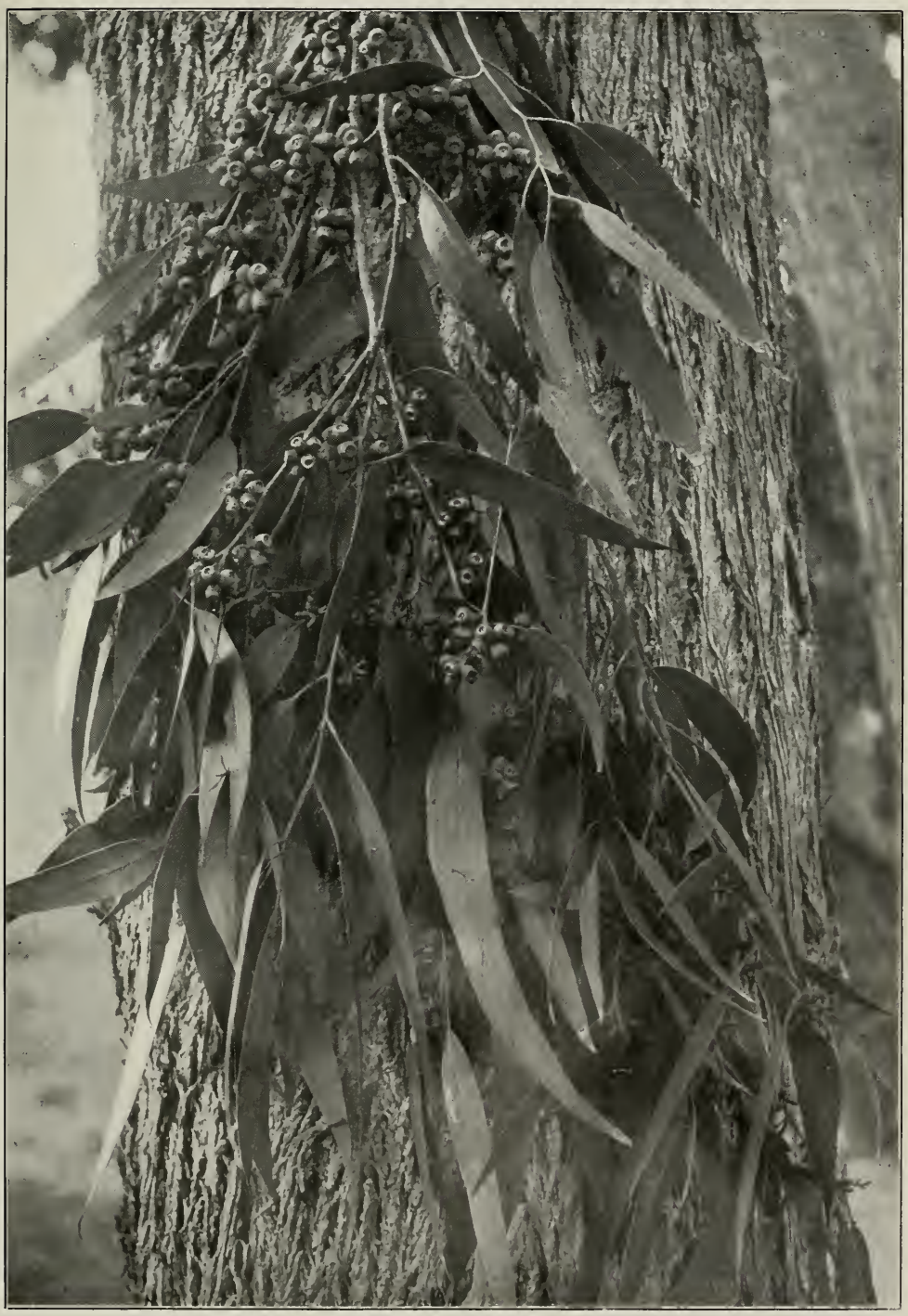
EUCALYPTUS CREBRA.

EUCALYPTUS DIVERSICOLOR.

EUCALYPTUS EUGENIOIDES.

EUCALYPTUS GLOBULUS.

EUCALYPTUS GOMPHOCEPHALA.



EUCALYPTUS GONIOCALYX.

plains and foothills, on the sides of low mountains, and in the warm, dry interior valleys. It will make some growth in the poor soil of hillsides, but prefers a fairly fertile soil. In Australia, according to Mr. Howitt and Mr. Maiden, it grows on both lowlands and highlands.

Uses.—The timber of the Yellow Box is very hard, tough, and durable, but is difficult to work and is not easily split. It is used in Australia for spokes, rollers, heavy framework, naves, and cogs. It is durable underground, and is consequently useful for telegraph poles and fence posts. It also makes an excellent fuel. On account of its profuse, fragrant bloom, it is coming to be highly prized as a source of honey.

Eucalyptus microtheca.

COOLIBAH.

Characteristics.—The Coolibah is a tree of medium size, generally more or less crooked, but of quite a pleasing appearance. The usual height in Australia is 50 to 80 feet and the diameter 2 to 4 feet. The few growing in America have quite erect trunks and give promise of becoming fair-sized trees. (Pl. XXXII.) It is one of the largest trees of the interior desert regions of Australia. The bark of the trunk is rough, generally furrowed, commonly persistent, and of a brownish-gray color (see Pl. LXVIII); that of the branches, white and deciduous. The wood is dark red or brown, and excessively hard and inlocked. The foliage is rather dense and inclined to droop. The leaves are long and somewhat curved, the two sides being equally dull green. The flowers are very small, in 3 to 8 flowered clusters, which usually grow in groups. The seed cases are very small and broadly top-shaped, with the valves protruding.

Climatic requirements.—The tree is indigenous to the dry, hot deserts of Australia, doing best in gravelly, well-drained soil. Baron von Mueller says of it, in his Eucalyptographia, that it will "brave a climatic temperature as torrid and as high as any on our planet, the thermometer rising in the shade, in places where this Eucalyptus grows, occasionally to 127° F." In his Select Extra-tropical Plants he states that it "withstands unscorched a frequent heat of 156° F." It also endures heavy frosts. It has grown well where it has been tried in the Southwest.

Uses.—As a forest cover for excessively hot, dry regions in the Southwest, this tree is quite a promising one. It furnishes a timber that is valuable for bridges, railway ties, posts, and for general building purposes. On account of the color and markings of the wood it is used for cabinetwork to some extent. The roots of this tree are used in a novel way by the natives of Australia. In common with a few other species of Eucalyptus this tree possesses water-yielding

roots, but the roots of this species yield more than those of any other. They are dug out, cut in pieces, and the water expelled by blowing at one end. According to Baron von Mueller, the aborigines depend entirely upon this source for water in many of their hunting expeditions, and frequently white settlers have found it convenient to obtain water from the same source. The planting of these trees on the deserts of the Southwest might prove a useful means of saving the lives of those crossing them.

Eucalyptus obliqua.

MESSMATE.

Characteristics.—This is a tall, straight-stemmed tree, sometimes attaining a height of 300 feet in Australia, with a stem diameter of 10 feet. The bark is fibrous and persistent on both the trunk and the branches, being of a somewhat grayish color. The leaves of the young trees are commonly broad (see Pl. LXXXVII, c), but they become narrower as the tree increases in age. They are commonly somewhat thick and stiff, and are conspicuously unequally sided toward the base. The latter characteristic causes them to set in a particularly noticeable manner obliquely to the stem, hence the specific name *obliqua*. (See Pl. LXIX.) The medium-sized flowers are very short stemmed, the stalks of the clusters being rather slender and slightly compressed. The shape of the mature seed cases is that of an egg with the smaller end cut away; or, in some cases, they are nearly hemispherical.

Climatic requirements.—This species grows fairly well at or near the coast, doing best, however, some distance inland, but it does not thrive in the dry, hot valleys of the interior. The fact that it extends well up into the mountains of Victoria and New South Wales, Australia, indicates that it is suitable for, and worthy of trial on, the lower mountains of the Southwest. It will thrive in light, barren soil, but does not endure severe drought.

Uses.—The timber of *Eucalyptus obliqua* is straight and easily split. In Australia this tree furnishes much of the hardwood lumber used for rough building purposes. It is also used extensively for fence rails, palings, and shingles. However, it does not last well underground. The bark has been used for paper making.

Eucalyptus occidentalis.

FLAT-TOPPED YATE.

Characteristics.—Individuals of this species vary considerably in habit of growth. Frequently they are shrubby in form, several stems rising from one root and growing to a height of 10 to 30 feet. (Pl. XXXIII.) Under more favorable conditions they are more tree-like,

and sometimes attain a height of over 100 feet in Australia. The bark of the trunk is in some cases smooth, in age casting off thin pieces, and in other cases quite rough and persistent. The branches are smooth and whitish, and are of about equal height, the characteristic giving the tree a flat-topped appearance. The bark of the small twigs is reddish brown. The leaves are of medium size and quite thick and shiny, the two sides being similar in appearance. (See Pl. LXXXII, c.) The flowers are large and quite conspicuous. The stalks of the clusters are flattened and the flower stems angled. The seed cases are somewhat bell-shaped or pear-shaped. (See Pl. LXX.)

Climatic requirements.—This species thrives at and near the coast, where the minimum temperatures are not below 25° F., and it endures the dry heat of the valleys, but is injured somewhat in the latter situations when the mercury falls below 25° F.

Uses.—The timber of this tree is hard and strong, and is used for fences, ties, posts, and fuel.

Eucalyptus paniculata.

White Iron Bark.

Characteristics.—The trees of this species are usually below medium size, the maximum height being something over 100 feet, and in some parts of Australia growing only to a height of 25 or 30 feet. In the Southwest it has not made a promising growth, few trees being yet over 6 inches in diameter. The bark of the trunk is usually hard, rough, and of a grayish-brown color. (Pl. XXXIV.) In some cases, however, it flakes off, leaving the stem smooth and grayish in color. The leaves are of medium size, being commonly lance-shaped, or somewhat curved. The flowers are abundant, below medium size, in clusters of 3 to 8, on rather slender, angled stalks. The seed cases vary from low cup-shaped to goblet-shaped.

Climatic requirements.—This Iron Bark grows fairly well near the coast and in the mountains, but does not endure heat and drouth well. At the Santa Monica forestry station it barely survived the drouth of 1899–1900.

Uses.—This tree furnishes a timber that is hard and durable, being one of the very valuable timber trees of Australia. It is useful wherever strength, hardness, and durability are desirable.

Eucalyptus pilularis.

Blackbutt.

Characteristics.—This is a shapely, good-sized tree, attaining in Australia, under favorable circumstances, according to Baron von Mueller, a height of 300 feet and a diameter of 15 feet. According to Maiden, the average height is 100 to 150 feet, with a diameter of 3 to 5 feet.

In the Southwest it has made a fairly rapid growth, but does not give promise of reaching a great size. The trees are inclined to be tall and slender, with little foliage near the ground. (Pl. XXXV.) The bark of the lower part of the trunk is dark gray, rough, and partially persistent, but from most of the trunk it flakes off in patches. The bark of the branches is smooth and light colored. The twigs are often conspicuously angled. The leaves are scattered, nearly lance-shaped, and about the same color on each side. The flowers are of medium size, in clusters of 4 to 16, on scattered stalks. The flower-bud coverings are conical. The seed cases are nearly spherical, or the shape of the broad part of an egg. The round form, resembling that of a pill, suggested the specific name *pilularis*.

Climatic requirements.—The Blackbutt grows along the coast of southeastern Australia, and to some extent on inland mountain slopes. In America it grows quite thriftily at and near the coast, but does not thrive in the dry, hot interior valleys, enduring neither very high nor very low temperatures.

Uses.—The strong and durable timber of the Blackbutt is used in Australia for house carpentry, for bridge and ship building, for telegraph poles, and for railway ties. Its slender growth makes it especially suitable for telegraph poles. It is considered one of the best all around timbers furnished by any Eucalypt. Fence posts of this timber are reported to last twenty years. The tree is an excellent honey producer, the honey from it being reported to be of an especially good quality.

Eucalyptus piperita.

White Stringy-bark.

Characteristics.—The trees of this species attain a considerable height and are commonly erect and quite shapely. The grayish bark of the trunk is fibrous and persistent. The leaves of the adult trees vary in shape from a broadly lance-shaped and very unequally sided to a narrowly lance-shaped and quite straight leaf. The young seedlings are clothed with distinct hairs. The flowers are of about medium size, in compact clusters of 6 to 12. The flower-bud coverings are cone-shaped or taper-pointed. The seed cases are the shape of the broader part of an egg or are nearly spherical.

Climatic requirements.—This tree makes a fairly rapid growth near the coast and in cool inland situations, but does not endure dry, hot climates, and will not tolerate heavy frosts.

Uses.—The timber is readily split and is used for fencing and general building purposes. It is one of the species eligible for planting for a forest cover on mountain sides where it is not too dry nor subject to too heavy frosts.

EUCALYPTUS GUNNII.

EUCALYPTUS HEMIPHLOIA.

EUCALYPTUS LEUCOXYLON.

EUCALYPTUS MACRORHYNCHA.

EUCALYPTUS MELLIODORA.

EUCALYPTUS MICROTHECA.

EUCALYPTUS OBLIQUA.

EUCALYPTUS OCCIDENTALIS.

Eucalyptus polyanthema.

Red Box.

Characteristics.—This is commonly a medium-sized tree, although it is said occasionally to reach a height of 250 feet in Australia. It is not a rapid grower, and few of the American specimens have attained a diameter of over 1 foot. It commonly sends up a single trunk, but quite frequently several stems arise from the same base. The tree is of a spreading habit, and, with its characteristic foliage and profuse bloom, presents a very pleasing appearance. (Pl. XXXVI.) The bark of the trunk and branches is persistent, somewhat furrowed, and grayish in color.

The leaves, both of the seedlings and of the adult trees, are roundish or broadly egg-shaped, and of an ashy or dull green hue on both sides. (See Pl. LXXXVII, B.) The bloom is profuse and dainty, the flowers being considerably below average size and arranged in branching clusters. (See Pl. LXXI.) The seed cases are somewhat top-shaped and, with their stems, are quite distinctly goblet-shaped. The margins are thin and often indented or split.

Climatic requirements.—This species thrives under a great variety of climatic conditions. It grows at and near the coast, in the foothills, on mountain sides, and in the hot, dry valleys of the interior. It endures minimum temperatures of 15° to 20° F. and maximum temperatures of 110° to 118° F. It is one of the few species tested at the Experiment Station farm near Phoenix that has been entirely uninjured by either the frosts of winter or the heat of summer. There are probably few situations in the Southwest below 3,000 feet elevation in which the tree would not grow.

Uses.—The timber of this tree is very hard, strong, and durable, being used in Australia for railway ties, for cogs, and for the parts of wheels. It also makes an excellent fuel. Upon account of the profuse bloom appearing at a time when sources of honey are limited, it is a useful tree for bee pasture. Its habit of growth and pleasing aspect render it a good shade tree. It can also be used as a wind-break in localities where faster growing trees will not endure the climatic conditions.

Eucalyptus populifolia.

Poplar-leaved Box.

Characteristics.—The tree is one of medium size, resembling considerably the preceding species. The bark is wrinkled and more or less furrowed, and is persistent. The leaves are scattered on rather long stalks, and are roundish or somewhat egg-shaped. They are very shiny and a deep green on both sides. The marginal vein of the leaves is some distance from the edge. The flowers are very small, in clusters

of 3 to 12 on very short stems. The stalks of the flower clusters are rather long and slender, being either single at the base of a leaf stem or in branching groups. The lid of the flower bud is hemispherical. The seed cases are very small and nearly top-shaped. (See Pl. XC.)

Climatic requirements.—This tree thrives in dry situations in California, and, judging by its Australian habitat, it could be grown even more successfully in the dry interior of the Southwest than its near relative, *Eucalyptus polyanthema*.

Uses.—This tree seems not to be sufficiently known either in Australia or in America to justify any conclusions as to its qualities or uses. It is reported to furnish durable posts, and probably in all its qualities closely resembles *Eucalyptus polyanthema*.

Eucalyptus punctata.

LEATHER-JACKET.

Characteristics.—The tree is of medium size, attaining in Australia a height of about 100 feet. It has a spreading habit, especially when young, not possessed by many Eucalypts. The bark is rough and of a dark color, and has a tendency to flake off. The leaves are lance-shaped or sickle-shaped, and thin. (See Pl. LXXXVIII, B.) The under surface is somewhat paler than the upper shiny one. The flowers are above medium size, in clusters of 3 to 10 on rather stiff, flattened stalks. The shape of the seed cases is nearly that of the broad part of an egg.

Climatic requirements.—This species thrives at and near the coast, but does not do as well in the dry interior.

Uses.—The wood of this tree is tough, hard, close-grained, and very durable. It is useful for fence posts, railway ties, and for the parts of wheels. It also makes an excellent fuel.

Eucalyptus resinifera.

RED MAHOGANY.

Characteristics.—This is a tree of fair size, when full grown, reaching a height of 100 feet. It is usually erect and symmetrical. The bark of the trunk is dark reddish, fibrous, and persistent, resembling considerably that of the Stringy barks. The bark of the branches is more or less deciduous. The wood is a rich, red color resembling true mahogany, and is very heavy. The leaves are slender and usually somewhat curved. (See Pl. LXXXVIII, A.) They are somewhat leathery in texture, and are considerably paler beneath than above. The veins spread like the parts of a feather. The flowers are of about medium size, in clusters of 4 to 10, on a somewhat compressed stalk. The buds are distinctly cream-colored, the lids being conical, with tapering points. The seed cases are cup-shaped or bell-shaped. (See Pl. LXXII.)

Climatic requirements.—The Red Mahogany grows quite well in the coast region of California, but does not thrive in the dry interior valleys. It does not resist severe frost, nor does it endure high temperatures in a dry atmosphere. It is well suited to moist, semitropical climates, being confined in Australia almost exclusively to the warm coast districts.

Uses.—The tree furnishes a timber that is very strong, hard, and durable. It is used in Australia for piles, posts, paving, shingles, and general building purposes. Mr. Maiden says in his "Useful Australian Plants:"

> This is one of the most valuable hard woods of the colony [New South Wales]. It is a rich red color, resembling true mahogany a good deal in appearance. It is a grand furniture wood where its weight is not against it. * * * It is one of the most durable timbers we have, being greatly resistant to damp and the attacks of white ants.

This Eucalypt can be used as a forest cover, as a shade tree, and as a wind-break where it is too moist and warm for other species, and will at the same time be a source of valuable timber.

Eucalyptus robusta.

SWAMP MAHOGANY.

Characteristics.—This is a tree symmetrical in form and of medium size. In the Southwest it has not yet exceeded a height of 50 feet and a diameter of 1 foot, but in Australia it is said to attain a height of 100 feet, with a trunk sometimes 50 feet long and nearly 4 feet in diameter. The heavy foliage and spreading habit give the tree a stately, robust appearance, hence its specific name, *robusta*. (See Pl. XXXVII.) The rusty gray bark is persistent and is usually wrinkled and furrowed. The bark of the branches frequently flakes off, leaving them smooth. The leaves are large and leathery, sometimes being 6 inches long and 2 inches wide. (See Pl. LXXIII.) The upper side is dark green, the lower a paler green color. The cream-colored flowers are large and quite abundant, growing in clusters of 3 to 10 on stout, usually flattened stocks. The seed cases are goblet-shaped, or sometimes urn-shaped, and occasionally slightly angled. (See Pl. XCI.)

Climatic requirements.—The tree thrives at and near the coast, but does not endure well the dry heat of the interior. In its native country it grows in warm, swampy coast localities, but in the Southwest it will grow in quite a variety of situations if supplied with sufficient water. It has been much planted as an avenue tree in the Southwest, but after a few years it usually makes an irregular, unsatisfactory growth, unless the roots are kept quite moist. It ought to thrive along the coast of the Gulf of Mexico, in regions free from heavy frosts.

Uses.—The wood of this tree is not in special favor with artisans; but as it is durable underground it is very useful for posts, ties, and similar purposes. According to Baron von Mueller it is free from the attacks of destructive insects, which is ascribable to the presence of kino.

Eucalyptus rostrata.

RED GUM.

Characteristics.—Individuals of this species make fairly rapid growth, and are commonly above medium size. The tree varies considerably in habit and appearance, in some cases being erect and stately, and in other cases unsymmetrical and irregular in growth. (Pls. XXXVIII, XXXIX.) The individuals also vary as to the hue of the foliage, that of some being a livid green, while that of others may be yellowish or reddish.

The Red Gum is one of the leading forest trees of the Australian continent. Baron von Mueller says of it that it is "perhaps the most important of the whole genus!" Mr. Maiden says, "I do not suppose that there is a person resident in Victoria or South Australia for six months who does not well know what Red Gum is;" and, in speaking of its occurrence in New South Wales, adds, "It is the tree which produces directly to the colony by far the most revenue of all our trees."

The tree is commonly about 100 feet high in Australia, but is reported under favorable circumstances to grow to double that height, with a trunk diameter of 6 to 12 feet. The bark of the younger trees is smooth and reddish or ashy gray; of the older ones usually more or less rough and furrowed. It is commonly persistent, but occasionally patches of varying thickness flake off. The stems of the young seedlings and the twigs of the trees are red. The leaves are of medium size, lance-shaped or sickle-shaped, and have the same color on the two sides. The flowers are small, on slender stems, in clusters of 3 to 12, borne on rather slender stalks. The deciduous covering of the flower bud is distinctly pointed or beaked, the Latin word for which is *rostratus*, giving the tree its specific name. The seed cases are cup-shaped, with conspicuous protruding valves. (See Pl. LXXIV.)

Climatic requirements.—The Red Gum grows under a great variety of climatic conditions. It is scattered over most of the southeastern part of Australia, growing there in a great variety of situations. While it prefers moist river bottoms with an equable climate, it will endure much heat, severe frost, and considerable drought. In the southwestern part of the United States it thrives at the coast, on the dry mesas, in the foothills, and in many of the dry, hot valleys of the interior. In the latter region it endures minimum temperatures of 15° to 20° F., and maximum temperatures of 110° to 115° F. It thrives in the moist, foggy sections of the coast regions of the Southwest, and

EUCALYPTUS POLYANTHEMA.

EUCALYPTUS RESINIFERA.

EUCALYPTUS ROBUSTA.

EUCALYPTUS ROSTRATA.

endures the desert conditions of southern Arizona. Near Phœnix, where the annual rainfall is only 7 inches, are trees that in ten years have attained a height of 30 to 45 feet and a basal diameter of 1 foot, with no irrigation since the first few years of their growth. (See Pls. XL, XLI.) Besides enduring such extreme climatic conditions as indicated, this species is also tolerant of considerable alkali.

The Red Gum seems to have become more nearly naturalized in the Southwest than any other species. As already stated, it grows spontaneously in considerable abundance on Mr. Cooper's ranch near Santa Barbara, the climatic and soil conditions of the ravine that extends through his estate seeming to resemble quite closely conditions under which the tree thrives in its native land. As the species becomes more generally planted it will, very probably, come to grow spontaneously under a variety of conditions.

Uses.—The Red Gum furnishes a timber that is very valuable for many purposes. When freshly cut, the wood is a rich red color that grows darker as it is exposed to the air. It is close-grained, the fibers being interlocked and thus rendering it quite difficult to split. It is very hard and strong—Mr. Maiden says "almost as hard as iron, when thoroughly dry." The great usefulness of the timber is due principally to its durability, both underground and in water. Baron von Mueller says, in his "Introduction to Botanical Teachings," that "well matured trees of this species, cut at the season when the circulation of the sap is least active, and carefully placed for drying, have proved one of the most durable of any timbers of the whole globe." According to this author and Mr. Maiden, the principal uses of the timber in Australia are for ship building, for bridge building, for paving, for telegraph poles, posts, piles, house blocks, and street curbing. It is reported to be quite resistant to the attacks of marine animals and white ants. Baron von Mueller says, "The timber is one of the most highly esteemed in all Australia among that of Eucalypts:" and Mr. Maiden, in speaking of this species in an address upon the forests of New South Wales, May, 1901, states that "there is no difficulty in supplying a practically unlimited demand for a timber of one uniform quality."

In Australia the Red Gum is a source of commercial kino, the article from this species being, according to Mr. Maiden, "perhaps the best known of all Eucalyptus kinos." Exudations are provoked by chopping a few chips from the bark of the trunk.

In America the principal uses made of the Red Gum have been for fuel and for posts. Mr. Cooper cuts it for fuel for home use and for market, and considers it a profitable species for that purpose. On account of its profuse bloom it is a good honey-yielding tree, both in Australia and in America. Besides the above, the species is useful as a shade tree, as a wind-break, and as a forest cover in a great variety

of situations. Owing to the great value of the tree from so many standpoints, no mistake will be made in setting it wherever it will thrive. It may be planted with profit as a forest cover in ravines, on hillsides, on plains, and in quite dry desert situations. Such plantations will within a decade begin to be sources of posts, fuel, railway ties, telegraph poles, and bridge timbers, and will eventually produce timber suitable for other important uses. If such plantings were made along railway tracks, ties for keeping them in repair would be available within a decade, and later the product would be sufficient for extensions of the road into new sections. Timbers for repairing railway bridges and building new ones, as well as for telegraph poles, could also be thus supplied within easy reach of the points where they would be needed.

Eucalyptus rudis.

Characteristics.—The trees of this species are commonly of medium size, the usual height being 50 to 75 feet. Near Fresno, Cal., a grove fifteen years of age contains trees 70 to 80 feet high and 18 to 24 inches in diameter. (Pls. XLII, XLIII.) The trees differ in habit, most being erect and stately, while occasionally others have drooping stems and branches. The young trees are vigorous and rapid growers, attaining in America half the maximum height reported for them from Australia in four or five years. The grayish bark of the trunk is usually rough and persistent, but sometimes flakes off, leaving the trunk smooth. The leaves of the young trees are oblong, or sometimes roundish, often with a deep red or bronze hue. (See Pls. LXXXIV, A; LXXXIX, A.) As the tree grows older the new leaves are longer and thinnish, finally being lance-shaped or curved. (See Pls. LXXV, LXXVI.) The flowers are about medium size, in clusters of 3 to 8, on rather slender stalks. The covering of the flower buds is conical. The seed cases are cup-shaped, with prominent protruding valves.

Climatic requirements.—If supplied with sufficient water the tree will thrive in quite a variety of climates. In Australia it grows naturally along or near streams. In the Southwest it thrives near the coast, on dry mesas, and in the hot valleys of the interior. At Phoenix, Ariz., one tree has attained a height of 30 feet and a diameter of 6 inches in three years, being unaffected by either the heat of summer or the cold of winter. In the Southwest the tree has proven to be remarkably hardy to heat and cold, enduring without injury minimum temperatures of 15° to 18° F. and maximum temperatures of 110° to 118° F.

Uses.—Few reports on the character of the timber and its uses in Australia are available, and the tree has not been grown extensively enough in America to obtain data on the subject here. In regions

where less hardy species can not be grown the species will be useful for shade, for wind-breaks, for fuel; and for honey. It may also prove useful for posts.

Eucalyptus saligna.

Characteristics.—A lofty, straight-stemmed tree, the usual height in Australia being 100 to 200 feet and the diameter 3 to 6 feet. No large trees of this species are known to exist in America, and those that have been set have not given promise of attaining great size. The bark of the trunk is grayish in color, and is rendered nearly smooth by the gradual flaking off of the outer layers. The leaves are lance-shaped, somewhat curved, and long-pointed, the lower side being paler than the upper. The flowers are of medium size, nearly stemless, in clusters of 4 to 8, on a much-flattened stalk. The covering of the unopened flower buds is nearly cone-shaped. The seed cases are commonly bell-shaped, with protruding valves.

Climatic requirements.—This species has not been planted extensively enough in America for its relation to climate to be established. Very few of the trees that had been planted survived the drought of 1897–1900 in the Southwest. In Australia this species is confined to the warmer coast regions; hence it could not be expected to endure very severe conditions in America.

Uses.—In Australia this tree is one of the important sources of lumber. The timber is reported to have great strength and durability. It is used for piles, for large beams, for railway ties, and for other purposes where strength and durability are important. The wood is a pale, reddish color, is straight-grained, and is easily worked. It is said by Mr. Maiden to be a favorite with carpenters, who use it for a great variety of building purposes. It is also used by shipwrights and by wheelwrights.

Eucalyptus siderophloia.

Broad-leafed Ironbark.

Characteristics.—The trees of this species attain in Australia a height of 100 feet or more, with a trunk diameter of 3 to 4 feet; and in the Southwest they give promise of growing to a fair size. As of other Ironbark Eucalypts, the bark is persistent and rough, with quite deep fissures. It is of a rusty color and somewhat flaky. (See Pl. XLIV.) The leaves are large and broad, usually rather thick, often much curved, and are of about the same color on the two sides. (See Pl. LXXXIII, A.) The flowers are of about medium size, in clusters of 2 to 8 on more or less angled stalks. The clusters grow either singly or in groups of 2 to 8, mainly at the ends of the twigs. (See Pl. LXXVII.) The long covering of the flower-bud is conical and sharp pointed. The seed cases with their stems are goblet-shaped.

Climatic requirements.—This species grows fairly well in quite a variety of situations in the coast region of California, but will not thrive in the dry, hot valleys of the interior. It will endure minimum temperatures of 18° to 20° F., and maximum temperatures of 110° to 112° F., but it makes very slow growth under such trying conditions.

Uses.—The timber of the Broad-leafed Ironbark, as of other Ironbarks, is strong and durable. It is used for bridge building, for posts, sleepers, railway ties, and for other similar purposes where strength and durability are desired. It makes a fair fuel, burning very slowly.

Eucalyptus sideroxylon.

Red Ironbark.

Characteristics.—The Red Ironbark is a tree of medium to large size. It usually grows erect, with an even trunk, having numerous side branches, especially towards the top. It never grows to a great height. The bark is the hardest and darkest of the Ironbarks, the color usually being a dark red or brown. It is furrowed and cracked, and studded with beads of the kino that exudes from it. The whole appearance of the tree, with its rough, dark bark, its silvery, narrow leaves, and daintily colored flowers is quite distinctive, contrasting strongly with the smooth-barked, broader-leafed species of the genus. (Pl. XLV.) The wood is a dark red, and is very hard and heavy. The leaves are narrowly lance-shaped, often curved, and usually have a more or less evident silvery surface, the leaves of the seedlings being very similar to those of the adult tree. (See Pl. LXXXVI, B.) The flowers are somewhat above medium size, in clusters of 3 to 8. In color they vary from a light pink to scarlet. The covering of the flower-bud is cone-shaped, often sharp-pointed. The seed cases are nearly cup-shaped. (See Pl. LXXVIII.)

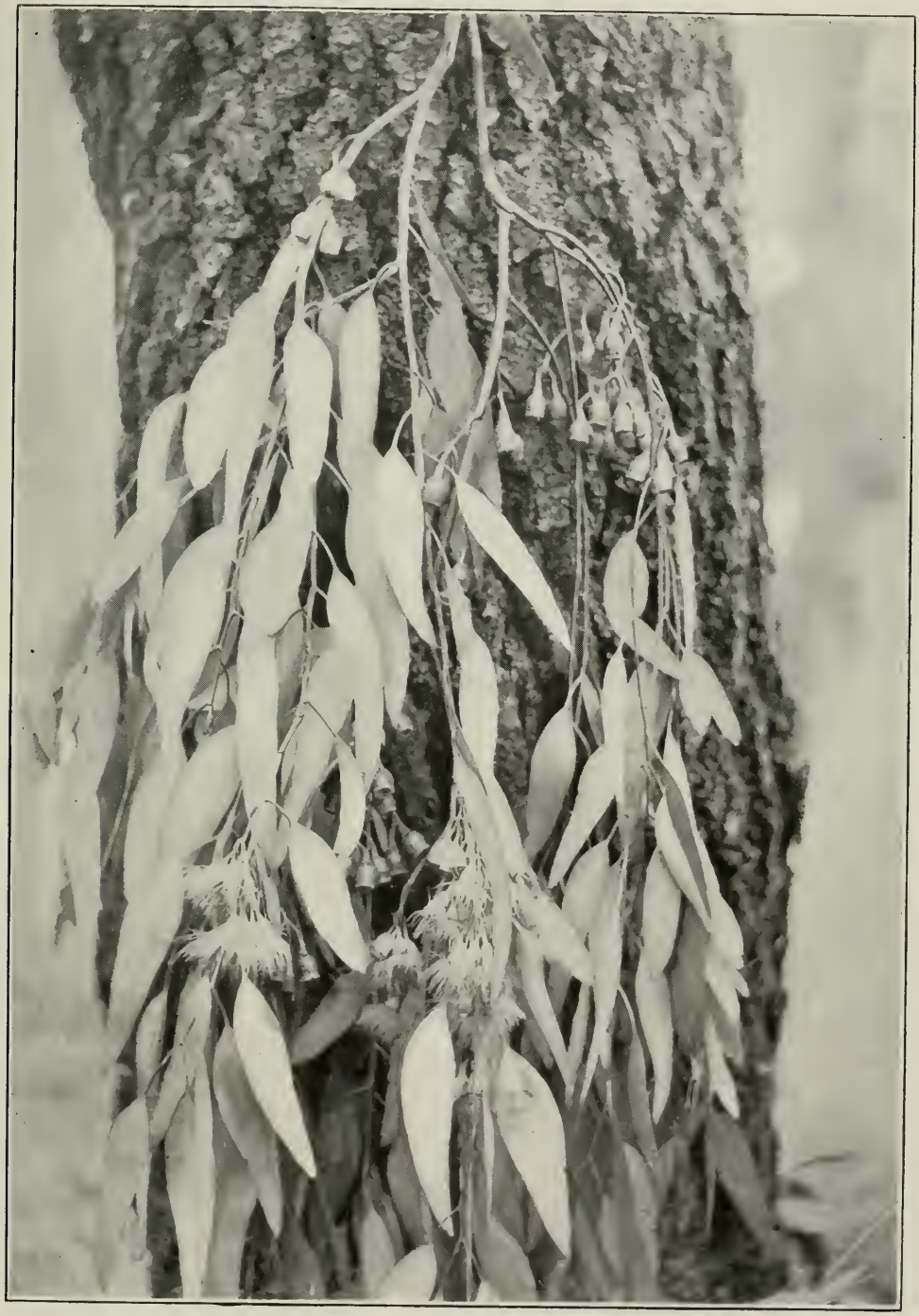
Climatic requirements.—In Australia the Red Ironbark is most abundant on the stony, sterile portions of gold-producing districts, enduring considerable drought and heat. In California it thrives in dry soil near the coast, and on the plains and hillsides of many of the interior valleys. It endures minimum temperatures of 16° to 20° F., and maximum temperatures of 110° to 112° F., but makes a very slow and indifferent growth under such conditions. It has proven to be entirely unsuited to the hot, interior valleys of California and Arizona.

Uses.—The Red Ironbark is one of the very useful Eucalypts. While the timber is not prized as highly in Australia as that of other Ironbarks, it is nevertheless valuable for many purposes. Its principal uses are for bridge construction, for railway ties, for girders and large beams in buildings, for joists, for posts, for the hubs, spokes, and shafts of vehicles, and for a great variety of other purposes where strength and durability are required. On account of its shape and

EUCALYPTUS RUDIS. TREE 12 YEARS OLD.

EUCALYPTUS RUDIS, TREE 6 YEARS OLD.

EUCALYPTUS SIDEROPHLOIA.



EUCALYPTUS SIDEROXYLON.

EUCALYPTUS TERETICORNIS.

EUCALYPTUS VIMINALIS.

A. EUCALYPTUS CALOPHYLLA.

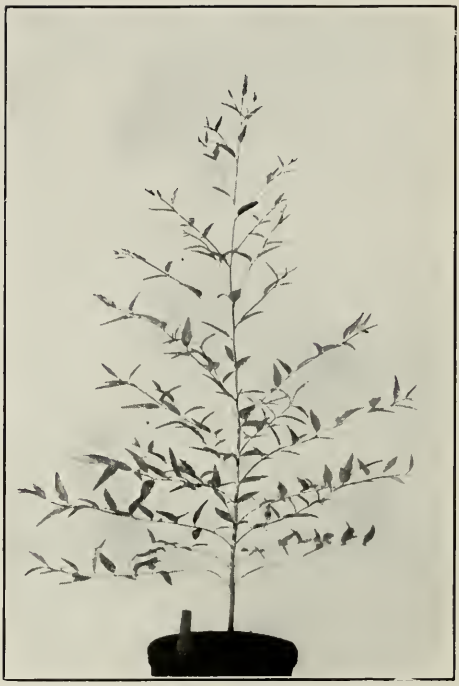
B. EUCALYPTUS CORYMBOSA.

C. EUCALYPTUS CORYNOCALYX.

D. EUCALYPTUS CITRIODORA.

EUCALYPT SEEDLINGS.

A. EUCALYPTUS CORIACEA.



B. EUCALYPTUS EUGENIOIDES.

C. EUCALYPTUS OCCIDENTALIS.

D. EUCALYPTUS CORNUTA.

EUCALYPT SEEDLINGS.

attractive aspect, it makes a desirable shade tree for many situations. As a wind-break it is also serviceable, and is a valuable source of honey. As a forest cover for situations too stony and sterile for the faster-growing species, it has considerable value. Railway companies would do well to consider the planting of this tree along portions of their lines running through moderately warm, dry regions, for the production of timber for bridges and track repairs.

Eucalyptus stuartiana.

Apple-scented Eucalypt.

Characteristics.—The trees of this species never attain a very great size, but they make a comparatively rapid growth during the first ten years, in some cases reaching a trunk diameter of 1 foot and a height of 30 to 40 feet during that period. The tree usually grows quite erect, with a somewhat stocky appearance. The bark of the trunk and main branches is rough and more or less fibrous. It is of a grayish brown color outside and is salmon colored next the wood. The leaves of the young seedlings and of young suckers are opposite on the stem, and roundish or lance-shaped, usually having a distinct bloom on the surface. (See Pl. LXXXIV, c.) The later leaves are scattered, lance-shaped, or sickle-shaped, shiny, and equally dark green on the two surfaces. When crushed they give forth a pleasant odor, somewhat resembling that of apples. The flowers are of medium size, usually in compact clusters of 3 to 8. The deciduous covering of the flower buds is cone-shaped. The seed cases are rather small, and are commonly nearly top-shaped.

Climatic requirements.—The species thrives at and near the coast, but does not do well in the dry, hot valleys of the interior. It endures minimum temperatures of 10° to 18° F., and it therefore may be planted in higher latitudes and at greater elevations than most species.

Uses.—Upon account of its resistance to frost, this Eucalypt is useful for a forest cover, for windbreaks, and for shade in ravines and on fairly moist hillsides and mountains where, on account of too heavy winter frosts, other species would not thrive. The tree furnishes a timber that is hard, but, not being straight-grained, is somewhat difficult to split. It is useful for fence posts and for fuel. According to Baron von Mueller, it is employed to some extent for furniture manufacture in Australia.

Eucalyptus tereticornis.

Forest Red Gum.

Characteristics.—The tree attains a good size under favorable conditions, but it is commonly not much above 100 feet in height and 6 feet in diameter in Australia. In the Southwest it makes quite a rapid

growth and gives promise of reaching fully the size the trees do in their native home. When growing near together, or among other trees, they are usually tall and straight, with even trunks, but when growing scattered they branch more and are more stocky. At Mr. Cooper's ranch near Santa Barbara their rate of growth has been about two-thirds that of the Blue Gum, the fastest-growing species. (Pl. XXV, B.) The bark is commonly smooth and grayish, frequently flaking off in thin layers.

The leaves of the young seedlings are broad, with very short stocks, but as the young tree increases in size the leaves that appear are more scattered, longer stalked, and more slender. (See Pl. LXXXVIII, C.) The flowers are above medium size, in open clusters of 4 to 8 on slender stalks. The deciduous covering of the full-grown flower bud is long, round, and usually abruptly sharp-pointed, the specific name—*tereticornis* (the Latin for "round-horned")—referring to this characteristic shape. The seed cases are usually below medium size, and are top-shaped or goblet-shaped, with prominent protruding valves. (Pl. LXXIX.)

Climatic requirements.—The species thrives under quite a variety of climatic conditions. It grows best near the coast, but endures the dry heat of the interior valleys. It will withstand minimum temperatures of 15° to 20° F., and maximum temperatures of 110° to 112° F. It also endures drought well.

Uses.—The trees of this species furnish an excellent red-colored timber that is very hard, heavy, and durable. It is used for general building purposes, for ship building, for wheelwright work, for railway ties, for telegraph poles, posts, fencing, and fuel, its characteristics and uses being much the same as those of *Eucalyptus rostrata*. By some the timber is considered more durable than that of the latter. Mr. Maiden reports a post of this timber that remained quite sound for fifty-five years; according to the same author, Mr. Howitt, the eminent authority on Victorian trees, places *E. tereticornis* at the head of all commercial timber trees of that colony.

Eucalyptus viminalis.

MANNA GUM.

Characteristics.—Both in Australia and in the Southwest the individuals of this species make rapid growth, and commonly become trees of large size. Baron von Mueller states that they sometimes reach a height of 300 feet and a trunk diameter of 15 to 30 feet. Those growing in the Southwest give promise of eventually attaining dimensions approaching the above. It is exceeded in rate of growth by the Blue Gum (*Eucalyptus globulus*) only. At Pasadena, Cal., an *E. viminalis*

tree 24 years old was measured that had a circumference of 16 feet (and therefore a diameter of over 5 feet) 2 feet from the ground, and an approximate height of 100 feet. (See Pls. XLVI, XLVII, XLVIII, XLIX.) The surface of the bark varies considerably in appearance. That of the trunk and main branches is commonly persistent, but from some trees long, slender, strips are shed, leaving the trunk smooth and of a greenish or reddish creamy color. The persistent bark is brownish in color, furrowed, and rough. The bark of the branches in nearly all cases flakes off, leaving them smooth. This tree has the peculiar characteristic of exuding a honey-like substance, called "lerp" by the natives, but better known as "manna," when the bark is punctured or wounded by insects.

The small branches, which are reddish, commonly droop considerably, sometimes giving the tree a willow-like appearance. The leaves of the young plant and of suckers are stemless, slender pointed, with broad bases, and placed opposite on the stem. On the older trees they are narrower, pointed at each end and set on stems. According to Baron von Mueller, the sap of the leaves is rich in sugar, there being over 13 per cent in them when dry. The flowers are of about medium size, on rather slender stalks. There is considerable variation in the number of flowers in each cluster. On some trees the flowers are quite uniformly in clusters of 3, but on others they are in clusters of 3 to 7. This variation in the inflorescence in conjunction with the variation in bark structure makes the species somewhat difficult to recognize. The covering of the flower buds is approximately cone-shaped, usually the shape of a low, broad cone. The seed cases are top-shaped, or nearly globular, the valves of those that have dropped their seeds protruding conspicuously. (See Pl. LXXX.)

Climatic requirements.—This Eucalypt grows under quite a variety of climatic conditions. In the Southwest it thrives near the coast, on dry mesas, in the elevated valleys of the interior, and in the hot valleys of much of the desert region. It endures minimum temperatures of 15° to 20° F., and maximum temperatures of 110° to 115° F. Thrifty specimens can be seen in the vicinity of San Francisco, Santa Barbara, and Los Angeles, Cal., at Yuma, Ariz., and near Phoenix, Ariz. (See Pls. XLVII, XLVIII, and XLIX.)

Uses.—The timber of this tree is less valuable than that of most Eucalypts. It is not durable underground and does not make the best of fuel. In Australia it is used for shingles and for rough building material. The tree can be grown for a forest cover, for wind breaks, for fuel, and for shade in many localities where a species producing a better timber can not be grown; but there are probably few situations where this tree can be grown in which a more desirable tree, such as the Red Gum (*Eucalyptus rostrata*), can not also be grown.

GROUPING OF SPECIES ACCORDING TO CHARACTERISTICS, CLIMATIC ADAPTATIONS, AND USES.

For convenience of reference, the species discussed in the preceding section are here grouped according to some prominent characteristic, climatic requirement, or use. It is hoped that this grouping will be helpful in determining the name of a tree in cases of ignorance or doubt, and will aid planters in deciding what species to plant in a particular locality, or for any special use. In selecting a species for a particular purpose, it will, of course, be necessary to take into consideration as well what species would be likely to thrive in the locality where the planting is to be done.

CHARACTERISTICS.

BARK.

Bark commonly smooth ("Gum trees"): *Eucalyptus citriodora*, *E. coriacea*, *E. corynocalyx*, *E. rostrata*, *E. saligna*, and *E. tereticornis*.

Besides the above, some individuals of several species have smooth bark, even when well grown; and it is to be remembered that the seedlings of all species have smooth bark, and that on some species the bark remains smooth several years longer than on others.

Some forms of *E. amygdalina*, *E. occidentalis*, and *E. viminalis* have quite smooth bark; and the bark of *E. botryoides* and *E. rudis* remains smooth until the trees are several years old.

Bark distinctly fibrous ("Stringy barks"): *Eucalyptus eugenioides*, *E. macrorhyncha*, *E. obliqua*, and *E. piperita*. The bark of the foregoing resembles quite closely that of American cedars.

Bark scaly and furrowed ("Box trees"): *Eucalyptus calophylla*, *E. cornuta*, *E. corymbosa*, *E. goniocalyx*, *E. gomphocephala*, *E. hemiphloia*, *E. longifolia*, *E. microtheca*, *E. polyanthema*, *E. populifolia*, and *E. stuartiana*. The bark of those designated as "Box trees" resembles considerably that of American ashes or maples. Besides this similarity of bark, most of the trees known by the above name in Australia have close wood of interlocked fibers.

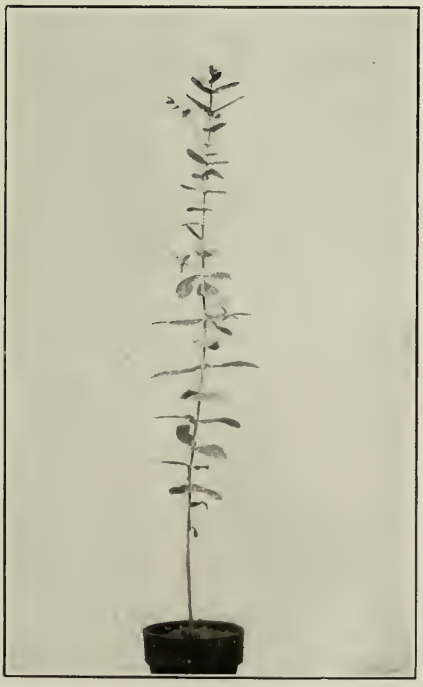
Bark hard and deeply fissured ("Ironbarks"): *Eucalyptus crebra*, *E. paniculata*, *E. siderophloia*, and *E. sideroxylon*. The typical "Ironbark" of the four is the last species named, the bark of the others being less pronounced as to hardness and unevenness.

LEAVES.

Leaves of seedlings opposite and stemless or short stemmed: *Eucalyptus coriacea*, *E. eugenioides*, *E. globulus*, *E. goniocalyx*, *E. leucoxylon*, *E. macrorhyncha*, *E. stuartiana*, and *E. viminalis*. Seedlings of the above species are quite marked in appearance, and, though

A. EUCALYPTUS SIDEROPHLOIA.

B. EUCALYPTUS DIVERSICOLOR.



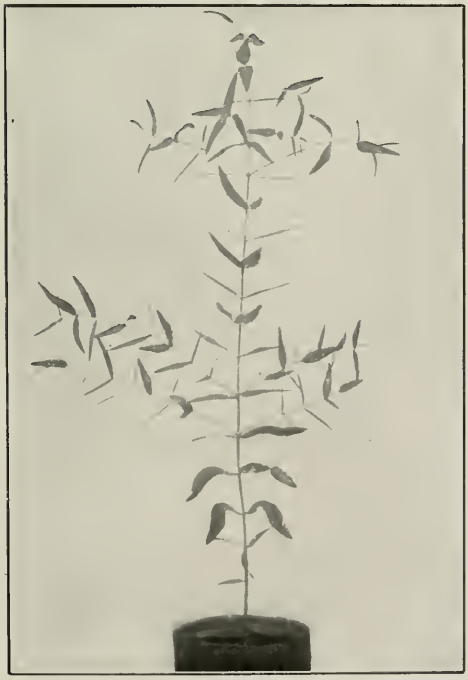
C. EUCALYPTUS GLOBULUS.

D. EUCALYPTUS GOMPHOCEPHALA.

EUCALYPT SEEDLINGS.

A. EUCALYPTUS RUDIS.

B. EUCALYPTUS GONIOCALYX.



C. EUCALYPTUS STUARTIANA.

D. EUCALYPTUS GUNNII.

EUCALYPT SEEDLINGS.

A. EUCALYPTUS PANICULATA.

B. EUCALYPTUS HAEMASTOMA.

C. EUCALYPTUS HEMIPHLOIA.

D. EUCALYPTUS CREBRA.

EUCALYPT SEEDLINGS.

A. EUCALYPTUS LEUCOXYLON.

B. EUCALYPTUS SIDEROXYLON.

On account of the similarity of the flowers and seed cases, these two species were confused in herbaria for many years.

C. EUCALYPTUS ROBUSTA.

D. EUCALYPTUS LONGIFOLIA.

EUCALYPT SEEDLINGS.

agreeing in one characteristic, differ considerably among themselves in other respects, especially in the shape of the leaves. None of these species have permanently opposite or stemless leaves.

Leaves of seedlings hairy: *Eucalyptus calophylla*, *E. citriodora*, *E. coriacea*, *E. eugenioides*, *E. macrorhyncha*, and *E. paniculata*.

Leaves permanently horizontal, darker above than below: *Eucalyptus botryoides*, *E. calophylla*, *E. corymbosa*, *E. diversicolor*, *E. resinifera*, *E. robusta*, and *E. saligna*. The foregoing species being all indigenous to the moister regions of Australia, the characteristic placing of the leaves vertically is not necessary. A few species, including *E. corynocalyx*, *E. diversicolor*, *E. pilularis*, and *E. punctata*, while not having their leaves so distinctly permanently horizontal, have leaves with the two surfaces more or unless unlike.

FLOWERS AND SEED CASES.

Flowers commonly in threes: *Eucalyptus leucoxylon*, *E. longifolia*, *E. viminalis*.

Flower clusters borne on a distinctly flattened stalk: *Eucalyptus botryoides*, *E. gomphocephala*, *E. goniocalyx*, *E. occidentalis*, *E. punctata*, *E. resinifera*, and *E. saligna*.

Flower-bud covering long and prominent: *Eucalyptus cornuta*, *E. marginata*, *E. occidentalis*, *E. siderophloia*, and *E. tereticornis*.

Seed cases large (one-half inch to 1½ inches in diameter): *Eucalyptus calophylla*, *E. corymbosa*, *E. globulus*, *E. gomphocephala*, *E. longifolia*, *E. marginata*, and *E. robusta*.

Seed cases very small (one-tenth to one-sixth inch in diameter): *Eucalyptus crebra*, *E. microtheca*, *E. polyanthema*, and *E. populifolia*.

CLIMATIC ADAPTATION.

In the following paragraphs an attempt is made to list species especially adapted to various climatic situations. It is not claimed that all that may be grown successfully in any one region are listed, but it is thought that the more promising ones are included.

Adapted to hot, humid regions: *Eucalyptus botryoides*, *E. calophylla*, *E. citriodora*, *E. cornuta*, *E. marginata*, and *E. resinifera*. Of the above, *E. botryoides*, *E. citriodora*, and *E. resinifera* are the most likely to thrive in America and to produce useful timber.

Adapted to warm, moderately humid regions having light winter frosts: *Eucalyptus amygdalina*, *E. botryoides*, *E. cornuta*, *E. corymbosa*, *E. corynocalyx*, *E. crebra*, *E. diversicolor*, *E. globulus*, *E. gomphocephala*, *E. goniocalyx*, *E. occidentalis*, *E. robusta*, *E. rostrata*, *E. rudis*, *E. sideroxylon*, *E. tereticornis*, and *E. viminalis*. Of the foregoing, *E. botryoides*, *E. diversicolor*, *E. globulus*, *E. gomphocephala*, and *E. tereticornis* seem best adapted to American climatic conditions, and most suitable for producing timber valuable for commercial purposes.

Adapted to situations not excessively warm during summer, but frosty during winter: *Eucalyptus amygdalina*, *E. crebra*, *E. eugenioides*, *E. gunnii*, *E. macrorhyncha*, *E. obliqua*, *E. leucoxylon*, *E. piperita*, *E. polyanthema*, *E. rostrata*, *E. rudis*, *E. saligna*, *E. stuartiana*, and *E. tereticornis*. Of these species *E. gunnii*, *E. leucoxylon*, *E. polyanthema*, *E. rudis*, and *E. tereticornis* will be most likely to give good results in the Southwest.

Adapted to dry regions free from heavy frosts: *Eucalyptus corynocalyx*, *E. crebra*, *E. diversicolor*, *E. globulus*, *E. gomphocephala*, *E. goniocalyx*, *E. leucoxylon*, *E. longifolia*, *E. pilularis*, *E. polyanthema*, *E. rostrata*, *E. rudis*, *E. sideroxylon*, *E. tereticornis*, and *E. viminalis*. Of the foregoing species *E. corynocalyx*, *E. crebra*, *E. diversicolor*, *E. globulus*, *E. leucoxylon*, *E. polyanthema*, *E. sideroxylon*, and *E. tereticornis* should give the best results in America and produce the most valuable timber.

Adapted to moderately moist mountain situations: *Eucalyptus coriacea*, *E. eugenioides*, *E. gunnii*, *E. leucoxylon*, *E. obliqua*, *E. piperita*, *E. rudis*, and *E. stuartiana*.

Adapted to regions dry and hot during summer and frosty during winter: *Eucalyptus corynocalyx*, *E. hemiphloia*, *E. leucoxylon*, *E. microtheca*, *E. polyanthema*, *E. rudis*, *E. tereticornis*, and *E. viminalis*.

Adapted to cultivation on alkali soils: *Eucalyptus cornuta*, *E. robusta*, and *E. rostrata*.

USES.

An attempt is made in the following pages to group the species of Eucalypts growing and fruiting in America according to the useful purposes for which they may be raised. It is not probable that all the species useful for any given purpose are included under the respective headings, but it is hoped that the most desirable ones have been noted. In selecting a species to grow for any given purpose, the question must be raised and answered as to whether it will be likely to thrive in the region where it is to be planted.

Useful for forest cover: (1) For mountains: *Eucalyptus coriacea*, *E. eugenioides*, *E. gunnii*, *E. leucoxylon*, *E. macrorhyncha*, *E. obliqua*, *E. piperita*, and *E. stuartiana*. (2) For plains and hills: *E. cornuta*, *E. corynocalyx*, *E. crebra*, *E. diversicolor*, *E. globulus*, *E. leucoxylon*, *E. rostrata*, *E. rudis*, *E. sideroxylon*, *E. tereticornis*, and *E. viminalis*. (3) For lowlands: *E. botryoides*, *E. citriodora*, *E. globulus*, and *E. robusta*. (4) For deserts: *E. corynocalyx*, *E. hemiphloia*, *E. leucoxylon*, *E. microtheca*, *E. polyanthema*, *E. tereticornis*, and *E. viminalis*.

Useful for wind-breaks: *Eucalyptus cornuta*, *E. globulus*, *E. leucoxylon*, *E. polyanthema*, *E. rostrata*, *E. rudis*, *E. sideroxylon*, *E. tereticornis*, and *E. viminalis*.

Since rapidity of growth is an important factor to be considered in

setting a wind-break, *Eucalyptus globulus*, *E. rudis*, *and E. viminalis* would be the most satisfactory ones of the above list. One of the three can be grown in most situations where a wind-break would be desired.

Useful for shade: *Eucalyptus botryoides*, *E. cornuta*, *E. corynocalyx*, *E. diversicolor*, *E. globulus*, *E. hemiphloia*, *E. leucoxylon*, *E. melliodora*, *E. polyanthema*, *E. robusta*, *E. rudis*, and *E. viminalis*. As there are few situations in the settled portions of the Southwest where one or more of the above will not grow, settlers may all have the pleasure of the shades of an evergreen wherever they may be located in that part of the United States.

Useful for fuel: *Eucalyptus botryoides*, *E. coriacea*, *E. corynocalyx*, *E. diversicolor*, *E. macrorhyncha*, *E. melliodora*, *E. obliqua*, *E. occidentalis*, *E. polyanthema*, *E. resinifera*, *E. rostrata*, *E. stuartiana*, and *E. tereticornis*.

Useful for posts, railway ties, and other underground purposes: *Eucalyptus botryoides*, *E. corymbosa*, *E. corynocalyx*, *E. crebra*, *E. eugenioides*, *E. goniocalyx*, *E. hemiphloia*, *E. longifolia*, *E. melliodora*, *E. microtheca*, *E. paniculata*, *E. pilularis*, *E. polyanthema*, *E. punctata*, *E. resinifera*, *E. robusta*, *E. rostrata*, *E. rudis*, *E. siderophloia*, *E. sideroxylon*, *E. stuartiana*, and *E. tereticornis*.

Judging from inquiries received by the writer and from statements made by farmers, there are few more important purposes that the Eucalypts are likely to serve than that of furnishing fence posts. From the above list one or more can be selected that will thrive in most of the various situations in the Southwest, as a reference to the grouping according to climatic adaptations will show. Probably the most generally useful of the list for posts is the Sugar Gum (*Eucalyptus corynocalyx*). It thrives in most situations in the Southwest; makes a fairly rapid growth; has a straight, even stem, especially when grown in blocks; and furnishes material for very durable posts. The Forest Red Gum (*E. tereticornis*) gives promise of proving nearly as useful for the above purposes.

Useful for piles: *Eucalyptus citriodora*, *E. globulus*, *E. hemiphloia*, *E. marginata*, *E. resinifera*, and *E. rostrata*.

Useful for street paving: *Eucalyptus citriodora*, *E. corymbosa*, *E. longifolia*, *E. pilularis*, *E. resinifera*, and *E. rostrata*.

Useful for telegraph poles: *Eucalyptus citriodora*, *E. pilularis*, *E. rostrata*, and *E. tereticornis*.

Useful for shipbuilding: *Eucalyptus diversicolor*, *E. globulus*, *E. pilularis*, *E. rostrata*, *E. siderophloia*, *E. sideroxylon*, and *E. tereticornis*.

Useful for vehicle making: *Eucalyptus botryoides*, *E. citriodora*, *E. cornuta*, *E. corynocalyx*, *E. diversicolor*, *E. globulus*, *E. goniocalyx*, *E. hemiphloia*, *E. melliodora*, *E. polyanthema*, and *E. punctata*.

Useful for agricultural implements: *Eucalyptus citriodora*, *E. cor-*

nuta, *E. corynocalyx*, *E. diversicolor*, *E. globulus*, *E. hemiphloia*, *E. pilularis*, *E. rostrata*, and *E. tereticornis*.

Useful for furniture and cabinet making: *Eucalyptus citriodora*, *E. microtheca*, and *E. resinifera*.

Useful as a source of oil: *Eucalyptus amygdalina*, *E. eugenioides*, *E. globulus*, and *E. rudis*.

Useful as a source of kino: *Eucalyptus calophylla*, *E. corymbosa*, *E. rostrata*, *E. siderophloia*, and *E. sideroxylon*.

Useful as a source of honey: *Eucalyptus calophylla*, *E. citriodora*, *E. corynocalyx*, *E. hemiphloia*, *E. leucoxylon*, *E. longifolia*, *E. melliodora*, *E. pilularis*, *E. polyanthema*, *E. rostrata*, *E. rudis*, *E. sideroxylon*, and *E. tereticornis*.

PART IV.

IDENTIFICATION OF EUCALYPTS.

Most of the seedling Eucalypts planted in the Southwest were not labeled when set out, and the identity of the adult trees thus usually became a matter of uncertainty. The identification of a particular Eucalypt tree is often of great importance. It may be one that is thriving in the situation in which it is growing, but unless its name be ascertained its value as a timber tree can not be known without putting the wood to an actual test, and thus destroying the tree. Or it may be known to be a desirable tree for some particular purpose or purposes, but the tree may not produce fertile seed from which it may be propagated. Moreover, a tree might thrive and produce fertile seed, but without a knowledge of its name the tree could not be written about or spoken of conveniently. Without knowing its name, seed or plants of the same species could not well be ordered by one desirous of obtaining them. It is also a matter of considerable interest to the possessor of Eucalypt trees to be able to establish for himself the identity of each of them. For the foregoing and for other reasons the identification of individual Eucalypts is a matter of great importance. The more thoroughly the tree is known from all standpoints, the more rapidly will information concerning it be disseminated. And the better the merits of the tree are understood, the more widely and extensively will it be planted.

It being necessary that students of Eucalypts pursue a more systematic method of identifying specimens of the genus than would be possible through the use of the preceding pages, the following treatment of the genus from a botanical standpoint is appended. The descriptions of the family to which the genus Eucalyptus belongs, and also the description of the genus and species are modified from those given in the works of Baron von Mueller, Mr. George Bentham, and Mr. J. H. Maiden. Descriptions are included of only those species the individuals of which reach at least 50 feet in height and 1 foot in diameter. Very brief descriptions are given of those species which have been discussed more fully in the preceding pages. Somewhat fuller descriptions are given of those not so fully treated previously. Brief statements are also made as to the utility of these latter species. What are supposed to be specimens of many of the 28 species described in the botanical part only of this publication are now growing in the South-

west. Not until they fruit, however, will their identity be fully established. As stated before, it was thought best to discuss in detail in the preceding pages only those species that have been positively identified in the Southwest by means of their flowers and seed-cases, leaving the other arboreal species to be mentioned only in this botanical section.

SYSTEMATIC POSITION OF THE EUCALYPTI.

The *Eucalypti* belong to the family Myrtaceæ, which may be characterized as follows:

Trees or shrubs; leaves opposite or alternate, usually dotted; flowers regular or nearly so. Calyx-tube grown to the ovary at the base or up to the insertion of the stamens. Petals usually as many as calyx-lobes, very much imbricated in the bud, the external one sometimes larger than the others, but usually all nearly equal when expanded, sometimes all concrete and falling off in a single operculum, or rarely entirely wanting. Stamens indefinite, usually numerous, inserted in one or several rows on a disk; filaments free or rarely united into a ring or tube at the base, or into as many bundles as there are calyx-lobes; anthers 2-celled, versatile, or attached by the base, the cells open in longitudinal slits, or rarely in terminal pores. Ovary inclosed in the calyx-tube, sometimes 1-celled, with a placenta attached to the base or adnate to one side; more frequently 2 or more celled, with the placentas in the inner angle of each cell; very rarely 1-celled with 2 parietal placentas. Style simple, with a small capitate or lobed stigma. Ovules 2 or more to each placenta, in 2 or more rows, or very rarely solitary. Fruit adnate to the calyx-tube, capsular and opening at the summit in as many valves as cells, or indihescent, dry and 1-seeded, or succulent and indihescent. Perfect seeds usually very few or solitary in each cell, even when the ovules are numerous, or rarely numerous and perfect.

The family is divided into four tribes, the Eucalypti falling into the tribe Leptospermæ (meaning "small seeds"), the chief characteristic of which is its 2 to 5 celled ovary opening at the summit by as many valves as there are cells. Of the genera belonging to this tribe, the genus Eucalyptus is by far the largest, including about 150 known species. This genus was first described by the French botanist L'Héritier in 1788. The first species discovered and described by him was *Eucalyptus obliqua*.

BOTANICAL DESCRIPTION OF GENUS.

Eucalyptus L'Her.

Evergreen trees, scattered as well as gregarious, sometimes of enormous height, some dwarfed shrubs, present in all parts of Australia in intratropic lowlands, in arid desert sands, and in alpine situations, occurring more scantily in New Guinea, in Timor, and very rarely in the Moluccas. Mostly of rapid growth, flowering occasionally at a very early age; bark either completely persistent or its outer layers deciduous; matured wood always hard; main branches usually distant; foliage often not dense; branches frequently pendent, usually quite glabrous, sometimes those of young plants rough, hairy. Leaves of old plants usually glabrous and thick in texture, usually scattered and with conspicuous stalks, in a few species opposite, and then generally without stalks, sometimes united; leaves of young plants frequently different in texture, position, and shape from those of older plants; the latter generally approaching in form to lanceolar-sickle-shaped, the upper and lower surfaces

A. EUCALYPTUS MELLIODORA.

B. EUCALYPTUS POLYANTHEMA.

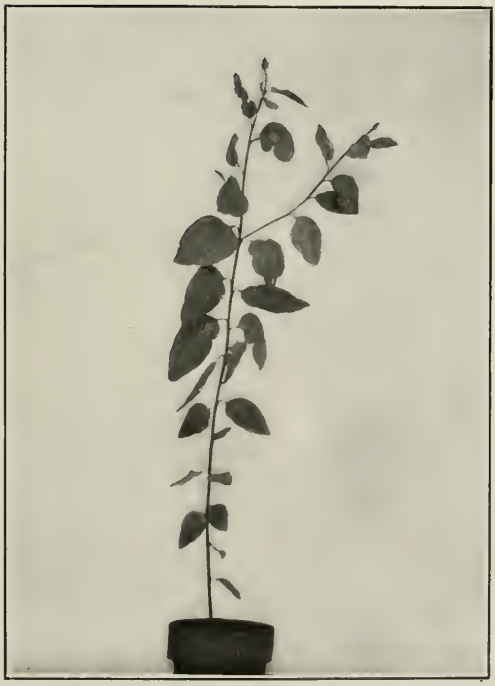
C. EUCALYPTUS OBLIQUA.

D. EUCALYPTUS PILULARIS.

EUCALYPT SEEDLINGS.

A. EUCALYPTUS RESINIFERA.

B. EUCALYPTUS PUNCTATA.



C. EUCALYPTUS TERETICORNIS.

D. EUCALYPTUS ROSTRATA.

EUCALYPT SEEDLINGS.

often of the same color and one edge of the leaf being turned upward and the other toward the ground; much less frequently considerably darker above and spreading horizontally; oil dots pellucid or concealed; peculiarly and strongly odorous; primary veins often numerous and much spreading. Inflorescence either axillary or terminal, or more rarely both modes united; flowers in single or paniculated umbels, rarely in twos, or solitary; umbel stalks and flower stalklets commonly present, the former sometimes much dilated; umbels while very young inclosed in a pair of fugacious and sometimes diminutive bracts; calyx very variable in size; lid often provided with a minute early deciduous accessory outer layer.

Calyx of firm texture and separated into a lower persistent portion and a deciduous lid. Petals none, unless represented in some few species by an inner membrane. Stamens very numerous, inserted close to the edge of the calyx tube in several rows, all fertile or some of the outer by absence of anthers sterile, always finally deciduous; filaments thread-like, pointed, inflexed while in bud, or the outer or very seldom all filaments straight before expansion; anthers dorsified, their two cells parallel or divergent, each opening by a marginal or anterior slit or less commonly by a pore. Style long; stigma convex or almost flat, undivided, seldom much dilated beyond the summit of the style. Ovary 2- to 6-celled, its lower portion grown to the calyx, its upper portion more or less free. Ovules in each cell numerous, the majority remaining unfertilized. Cotyledons broad, much compressed, somewhat folded, undivided or 2-lobed, curved around the cylindrical straight, erect radicle. Fruits for a long while persistent, form very small in some species to remarkably large in others, oftener smooth than streaked or ridged, valves always glabrous, very rarely permanently connected by the persistent base of the style. Seeds long retained in the persistent fruit, but soon shed on detachment of the latter; fertile seeds usually outside, dark brown; sterile seeds mostly pale brown and smaller than the others.

DETERMINATION OF SPECIES.

To identify the species of so large a genus is a difficult task. The system of identification adopted below is based on the structure of the anthers, the position of the valves, the shape of the lid, the form of inflorescence, and the similarity or dissimilarity of the two leaf surfaces. The first thing to ascertain about a Eucalypt that one wishes to identify by the use of the key below is the structure of the anthers. This can usually be done with a good lens by examining anthers from buds just ready to open. In using the key, the second thing to ascertain is whether the valves of a mature seed case are inclosed within it or project partly or wholly from the mouth. It is hoped that the accompanying plates will aid in the work of identification. (Pls. XC and XCI.)

It must be understood that all specimens will not plainly fall into any particular subdivision of the genus, and can not therefore be readily identified, especially by a beginner. But with a little patience and wider experience it will be found that most trees can be identified by the use of the keys and reference to the descriptions and illustrations. When a specimen has been traced to the species to which it is thought to belong, it should be ascertained if the species has been treated in detail earlier in the publication. If so, reference to the description and to the illustrations of the species in question will aid

in verifying or correcting the identification. The descriptions that follow apply to adult trees only.

ARTIFICIAL KEY TO SPECIES.

Anthers broader than long, usually kidney-shaped, and opening by slits that when joined are nearly horseshoe-shaped ..... *Renantherex*
- Valves completely inclosed:
  - Lid hemispheric:
    - Veins running longitudinally 1
    - Veins spreading from midrib:
      - Leaves of adult trees mostly opposite 3
      - Leaves of adult trees alternate:
        - Leaves oblique, broad 9
        - Leaves not oblique, narrow:
          - Leaves equally green above and below 2, 12
          - Leaves paler beneath 8
  - Lid not hemispheric:
    - Leaves equally green above and below 4, 5
    - Leaves paler beneath 6, 7
- Valves partly exserted:
  - Lid hemispheric:
    - Leaves equally green above and below:
      - Fruits semiovate 13
      - Fruits urn-shaped 16
    - Leaves paler beneath 14
  - Lid not hemispheric 15
- Valves completely exserted:
  - Lid hemispheric 10
  - Lid sharp-pointed 11

Anthers not or hardly broader than long, opening by two pores ..... *Porantherex*
- Valves deeply inclosed:
  - Leaves equally green above and below 23
  - Leaves paler beneath 17
- Valves completely but not deeply inclosed:
  - Leaves of adult trees broad 21, 22
  - Leaves of adult trees elongated:
    - Umbels paniculated 23
    - Umbels solitary:
      - Flowers in threes 18
      - Flowers not in threes 19, 20
    - Umbels solitary or racemose 24
- Valves barely inclosed 25

Anthers as long as or longer than broad, opening by nearly parallel slits ..... *Parallelantherex.*
- Valves completely inclosed:
  - Umbels solitary:
    - Leaves equally green above and below:
      - Leaves opposite 42
      - Leaves alternate:
        - Flowers mostly in threes 42, 62
        - Flowers 3 to 8:
          - Calyx angled 62
          - Calyx not distinctly angled 32, 51

Anthers as long as or longer than broad, etc.—Continued.
Valves completely inclosed—Continued.
Umbels solitary—Continued.
Leaves paler beneath:
Stalk broadly compressed 60, 61, 63
Stalk not broadly compressed:
Lid broader than calyx 38
Lid not broader than calyx 33
Umbels paniculated:
Leaves equally green above and below:
Leaves lemon-scented 40
Leaves not lemon-scented 37, 39, 41
Leaves paler beneath:
Fruits less than one-half inch in length:
Stalks broadly compressed 55
Stalks not broadly compressed 27
Fruits over one-half inch in length:
Stalklets short or none 35
Stalklets long 34, 36
Valves partly exserted:
Umbels solitary:
Leaves equally green above and below:
Stalklets broadly compressed, or angular:
Lid acute 51, 55
Lid not acute 56, 57
Stalks not broadly compressed:
Fruits large, 1 inch in diameter 67
Fruits small:
Leaves broad 44
Leaves narrow 49, 53
Leaves paler beneath:
Lid hemispheric 57
Lid pointed 59
Umbels paniculated:
Stalk broadly compressed 59
Stalk not broadly compressed:
Stalklets thick and angular 30
Stalklets slender and round 26
Valves completely exserted:
Umbels solitary:
Leaves equally green above and below:
Lid short, below one-fourth inch in length:
Lid sharp-pointed 47
Lid blunt:
Leaves broad 44
Leaves slender:
Valves long and slender 31
Valves short:
Flowers in threes 46, 52
Flowers more than 3 ..... 45, 46
Lid long, above one-fourth inch in diameter:
Valves coherent 64
Valves not coherent 48, 54

Anthers as long as or longer than broad, etc.—Continued.
Valves completely exserted—Continued.
Umbels solitary—Continued.
Leaves paler beneath:
Lid broader than calyx 64
Lid not broader than calyx 57, 58
Umbels paniculated:
Leaves equally green above and below 29
Leaves paler beneath 28

BOTANICAL DESCRIPTION OF SPECIES.

RENANTHEREÆ.

1. **E. coriacea** A. Cunn. Leaves elongated, thick, shining, equally green above and below, veined longitudinally; umbels solitary, lid hemispheric; fruits truncate-ovate, border of orifice depressed, valves inclosed.

2. **E. amygdalina** Lab. Leaves thin, equally green above and below; veins not much spreading, oil-dots copious, transparent; umbels solitary, flowers small, lid almost hemispheric; fruits truncate-ovate, border depressed, valves inclosed.

3. **E. risdoni** Hook. Leaves, sometimes all, even on the flowering branches, opposite, ovate-cordate and more or less connate, or sometimes those of the flowering branches alternate, broadly lanceolate and falcate, rather thick, with oblique veins scarcely conspicuous, the intramarginal one at a distance from the edge. Peduncles axillary or lateral, terete or angular, bearing each an umbel of 4 to 8 flowers. Fruit subglobose-truncate, the rim rather broad, flat; valves inclosed. Bark smooth, coming off in regular patches, varying from whitish to dark brown.

Adapted to cool, moist regions.

4. **E. stellulata** Sieb. Leaves small, thick, equally green above and below, veined longitudinally; umbels solitary, flowers very small, numerous, lid semiovate-conical; fruits truncate-globular, border depressed, valves inclosed. Bark rough, scaly and fibrous.

Adapted to cool, moist regions.

5. **E. eugenioides** Sieb. Leaves equally dark green above and below, shining, very inequilateral at the base, much transparently dotted; umbels mostly solitary, lid semiovate; fruits truncate-globular, border depressed, valves barely inclosed.

6. **E. piperita** Sm. Leaves less shining beneath, with many transparent dots; umbels solitary, lid semiovate-conical; fruits truncate-ovate, border compressed, valves inclosed.

7. **E. pilularis** DC. Leaves rather less shining beneath; umbels mostly axillary, their stalks compressed, lid semiovate-conical; fruits truncate-ovate, border depressed, valves inclosed.

8. **E. acmenoides** Sch. Leaves paler beneath; umbels mostly axillary, their stalks slender, lid hemispheric, pointed; fruits truncate-ovate, border compressed, valves barely inclosed. Bark rough, persistent, and fibrous.

Adapted to tropical coast regions. Timber valuable.

9. **E. obliqua** L'Her. Leaves equally green above and below, shining, very inequilateral at the base; umbels solitary, calyces granular-rough, lid hemispheric; fruits truncate-ovate, border compressed, valves inclosed.

10. **E. capitellata** Sm. Leaves thick, elongated, rather less shining beneath, very inequilateral at the base; umbels axillary, stalklets none, lid hemispheric; fruits semiovate below, border broad, convex, emersed, valves much exserted. Bark stringy and persistent.

Adapted to cool, moist regions. Furnishes a valuable timber.

11. **E. macrorhyncha** F. v. M. Leaves elongated, equally green above and below; umbels solitary; calyx lid concavely attenuated, sharply pointed; fruits below hemispheric, border convex, emersed, valves much exserted.

12. **E. haemastoma** DC. Leaves equally green above and below, very shining; umbels solitary, stalks somewhat compressed; outer stamens sterile; fruits semiovate, border depressed, valves very short, inclosed.

13. **E. sieberiana** F. v. M. Leaves elongated, thick, pale, equally green above and below, shining; veins thin, not much spreading; umbels solitary, their stalks compressed, lid hemispheric; outer stamens sterile; fruits truncate-ovate, border depressed, valves very short, barely inclosed. Bark rough and persistent.

Grows to an elevation of 4,000 feet in Australia. Timber valuable.

14. **E. microcorys** F. v. M. Leaves thin, much paler beneath, much transparently dotted, veins spreading; umbels partly paniculated, stalklets elongated, lid very small, hemispheric; outer stamens sterile; fruits hemiellipsoid, border compressed, valves minute, barely inclosed. Bark rough and persistent.

A large tree, furnishing a hard, durable timber. Adapted to moist semitropic regions.

15. **E. marginata** Sm. Leaves paler beneath, veins spreading; umbels solitary, lid conical; outer stamens straight in bud; fruits globular-ovate, truncate, border compressed, valves very short, barely inclosed.

16. **E. baileyana** F. v. M. Leaves thin, equally green above and below, with many transparent dots; umbels mostly solitary; lid hemispheric; fruits globular-urn shaped, border compressed, valves barely inclosed. Bark fibrous and persistent.

Does quite well on very poor sandy ridges. Wood tough and durable.

PORANTHEREÆ.

17. **E. paniculata** Sm. Leaves rather thin, paler beneath, umbels mostly paniculated; lid thin, conical-semiovate; outer stamens sterile; anthers truncated, opening at the summit; stigma much dilated; fruit semiovate, border of orifice compressed, valves inclosed.

18. **E. leucoxylon** F. v. M. Leaves equally dull green above and below; umbels solitary, mostly three-flowered, stalklets elongated; lid semiovate pointed; outer stamens sterile, anthers truncated, opening at the summit; stigma much dilated; fruits semiovate, border compressed, valves inclosed.

19. **E. sideroxylon** A. Cunn. Leaves equally green above and below, narrow, often glaucous; umbels solitary, several-flowered, stalklets elongated; lid semiovate pointed; anthers truncate, opening at the summit; fruits semiovate, valves inclosed.

20. **E. melliodora** A. Cunn. Leaves equally dull green above and below; umbels solitary; flowers small; lid conic-hemispherical; outer stamens sterile; anthers truncated, opening at the summit; stigma much dilated; fruits truncate-ovate, border compressed, valves inclosed.

21. **E. polyanthema** Sch. Leaves broad, equally dull green above and below; umbels paniculated; lid almost hemispheric; outer stamens sterile; anthers truncated, opening at the summit; fruit truncate-ovate, border compressed, valves inclosed.

22. **E. populifolia** Hook. Leaves broad, equally green above and below, shining, long-stalked, with many transparent dots; stalklets very short; umbels paniculated; lids hemispheric; fruit small, semiovate, border rather depressed, valves close to the summit, barely inclosed.

23. **E. hemiphloia** F. v. M. Leaves thick, elongated, equally green above and below; umbels paniculated; calyces somewhat angular; lid semiovate-conical; fruit hemiellipsoid, border compressed, valves inclosed.

24. **E. bosistoana** F. v. M. Leaves narrow, equally dull green above and below, copiously dotted with translucent oil glandules, lateral veins distant and much divergent, marginal vein distant from the edge; umbels solitary or racemosely arranged, few flowered; stalks elongated, generally somewhat compressed; calyx tube slight angular; lid semiovate-hemispheric; fruits small, nearly semiovate, valves inclosed. Bark rough on the lower part of the trunk, smooth on the upper.

Adapted to low lands in fairly humid regions. Timber valuable.

25. **E. largiflorens** F. v. M. Leaves thin, equally dull green above and below; umbels paniculated; lid double, the inner hemispheric, less wide than the calyx tube; outer stamens sometimes sterile; fruit small; lid hemispheric; fruit truncate-ovate, border rather compressed, valves inclosed.

PARALLELANTHEREÆ.

26. **E. crebra** F. v. M. Leaves narrow, thin, equally dull green above and below, veins spreading; umbels mostly paniculated; flowers small; lids semiovate-conical; stigma dilated; fruits small, semiovate, border compressed, valves short, somewhat exserted. Bark rough and persistent.

27. **E. howittiana** F. v. M. Leaves much paler beneath; umbels paniculated; stalklets none; flowers very small; lid conical, acute, pale; fruits minute, truncate-globular, border compressed, valves inclosed. Bark rough, somewhat fibrous, and persistent.

Useful as a shade tree. Wood valuable. Particularly adapted to tropical regions.

28. **E. raveretiana** F. v. M. Leaves thin, somewhat paler beneath; oil-dots pellucid; umbels paniculated; lid conical, acute; fruits minute, semiglobular beneath, border compressed, valves much exserted. Bark usually rendered smooth by the peeling off of the outer layer. Tree attains a gigantic size.

Promising for swampy situations in tropics. Wood very hard and durable.

29. **E. microtheca** F. v. M. Leaves equally dull and pale green; umbels paniculated; lid semiovate; fruits small, semiglobular beneath, border compressed, valves much exserted.

30. **E. siderophloia** Benth. Leaves elongated, equally green above and below; umbels partly paniculated; lid conical, very acute; outer stamens straight in bud; fruits semiovate, border compressed, valves somewhat exserted.

31. **E. salmonophloia** F. v. M. Leaves equally green above and below, shining; oil-dots numerous; umbels solitary; stalks slender, stalklets short; lid semiovate-conical; outer stamens straight in bud; fruit small, semiovate, border compressed, valves long-pointed, much exserted. Bark smooth.

Promising for dry interior valleys.

32. **E. patens** Benth. Leaves thin, elongated, almost equally dull green above and below; umbels mostly axillary; lid nearly hemispheric; fruits truncate-ovate, somewhat streaked, border compressed, valves inclosed. Bark rough and persistent.

Timber not particularly valuable.

33. **E. diversicolor** F. v. M. Leaves elongated, much paler beneath; umbels solitary; lid nearly hemispheric; fruits truncate-ovate, attenuated at the base, border compressed, valves inclosed.

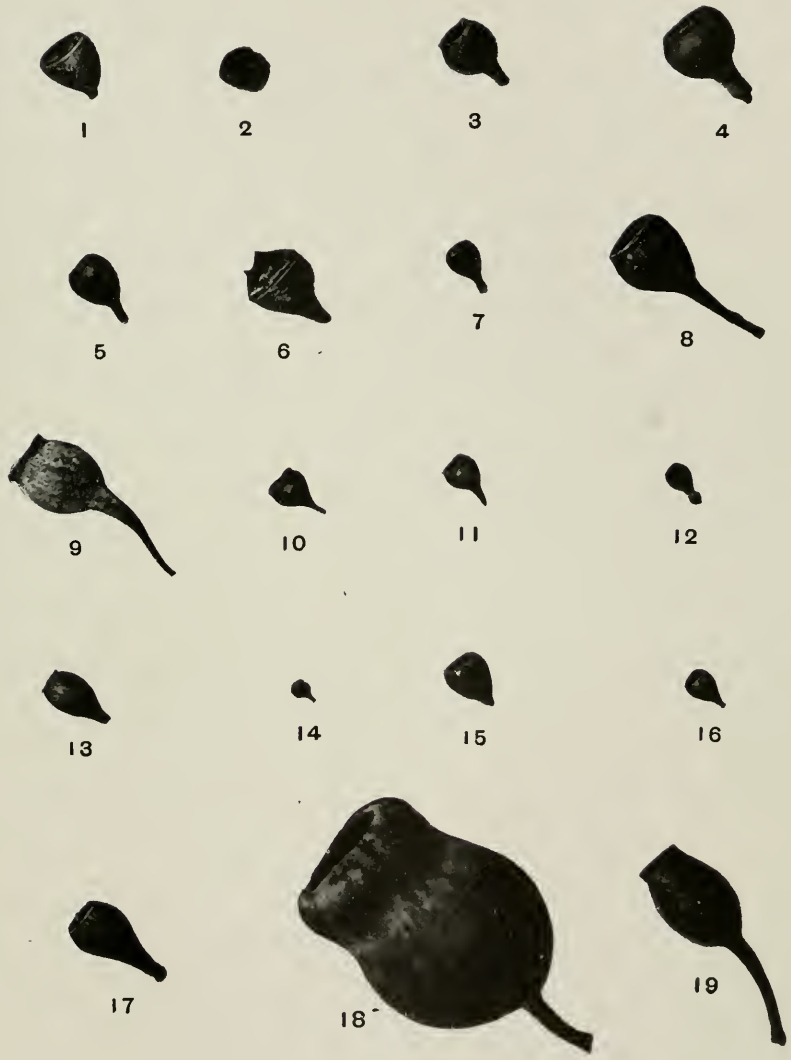
34. **E. calophylla** R. Br. Leaves broad, acute, much paler beneath, veins feather-spreading; umbels paniculated; stalklets elongated; lid patellar, less wide than the calyx tube, tearing off along an irregular suture; fruits large, smooth, ovate urn-shaped; border compressed, valves inclosed; fertile seeds, terminating in a large membrane.

35. **E. abergiana** F. v. M. Leaves thick, broadish, acute, much paler beneath;

A. EUCALYPTUS RUDIS. 1 YEAR OLD.

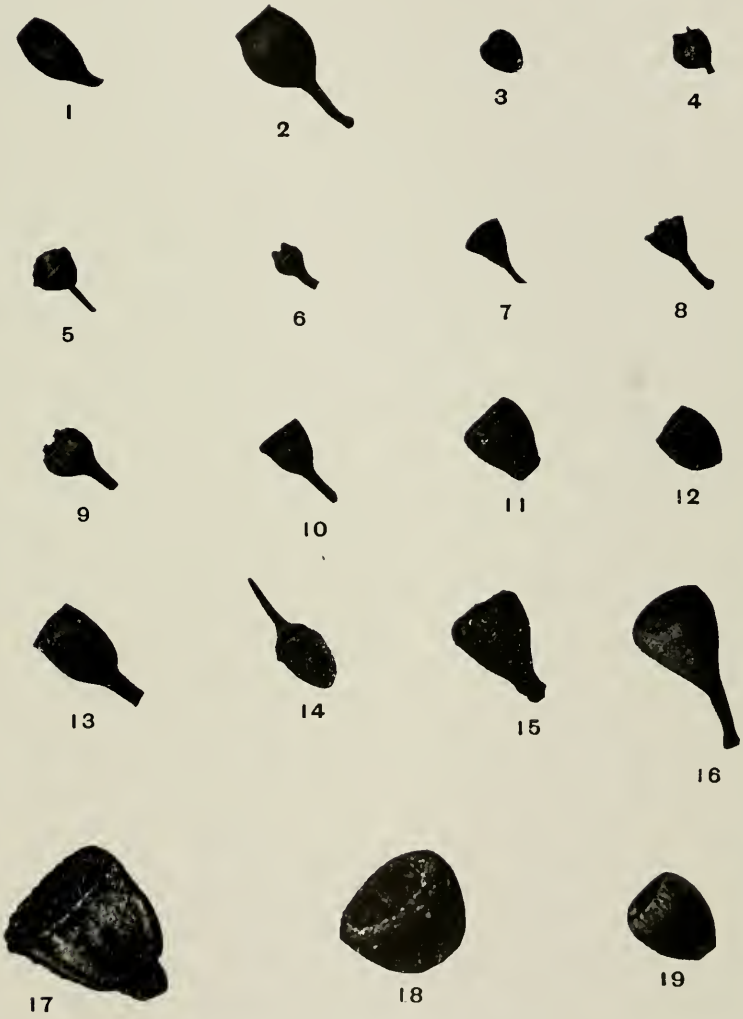
B. EUCALYPTUS POLYANTHEMA. 2 YEARS OLD.

YOUNG EUCALYPTS AT EXPERIMENT STATION FARM, PHOENIX, ARIZ.



EUCALYPTUS FRUITS. NATURAL SIZE.

1, Eucalyptus amygdalina; 2, E. eugenioides; 3, E. piperita; 4, E. pilularis; 5, E. obliqua; 6, E. macrorhyncha; 7, E. paniculata; 8, E. leucoxylon; 9, E. sideroxylon; 10, E. melliodora; 11, E. polyanthema; 12, E. populifolia; 13, E. hemiphloia; 14, E. microtheca; 15, E. siderophloia; 16, E. crebra; 17, E. diversicolor; 18, E. calophylla; 19, E. corymbosa.



EUCALYPTUS FRUITS. NATURAL SIZE.

1, Eucalyptus corynocalyx; 2, E. citriodora; 3, E. stuartiana; 4, E. viminalis; 5, E. rostrata; 6, E. tereticornis; 7, E. gunnii; 8, E. rudis; 9, E. resinifera; 10, E. punctata; 11, E. botryoides; 12, E. goniocalyx; 13, E. robusta; 14, E. cornuta; 15, E. occidentalis; 16, E. longifolia; 17, E. globulus; 18, E. gomphocephala; 19, E. coriacea.

veins feathery-spreading; umbels paniculated; stalklets almost none; lid hemispheric; tearing off along an irregular suture; fruits large, smooth, ovate-urnshape, border compressed, valves inclosed; fertile seeds terminating in a large membrane. Bark rough and persistent.

A large tree, promising for tropical countries.

36. **E. corymbosa** Sm. Leaves thick, broad to narrow lanceolate, much paler beneath; veins feathery-spreading; umbels paniculated; stalklets elongated; lid short, tearing off along an irregular suture; fruits rather large, smooth, ovate-shaped, border compressed, valves inclosed; fertile seeds terminating in a very short membrane.

37. **E. tessellaris** F. v. M. Leaves narrow, elongated, equally green above and below; umbels mostly paniculated; stalklets very short; lid patellar, shining; fruits truncate-ovate, slightly urceolar; border compressed, valves inclosed; fertile seeds almost flat, membraneous-margined. Bark rough and persistent on the lower part of the trunk; remainder of trunk smooth.

Promising for hot, dry regions free from frost.

38. **E. corynocalyx** F. v. M. Leaves shining, somewhat paler beneath; umbels mostly solitary; lid almost hemispheric, slightly overreaching the orifice of the calyx; fruits urnshaped-ellipsoid, streaked; border compressed, valves inclosed.

39. **E. maculata** Hook. Leaves elongated, equally green above and below; veins feathery-spreading; umbels paniculated; stalklets short; lid double, hemispheric, the inner thin, shining; fruit truncate-ovate, somewhat urnshaped, border compressed, valves inclosed. Bark smooth, falling off in patches and thus giving the trunk a spotted appearance.

Thrives on stony ridges; susceptible to frost; wood useful for paving.

40. **E. citriodora** Hook. Leaves long and narrow, equally shiny green above and below, veins spreading; umbels paniculated; stalklets short; lid hemispheric; fruit truncate-ovate, somewhat urn-shaped, border compressed, valves inclosed.

41. **E. eximia** Sch. Leaves thick, elongated, equally green above and below; umbels paniculated; stalklets none; lid thin, hemispheric, shining, imperfectly double; fruit rather large, truncate ovate, somewhat urnshaped, border compressed, valves inclosed; fertile seeds large. Bark rough and persistent.

A medium-sized tree furnishing good fuel.

42. **E. cordata** Lab. Leaves opposite, sessile, mostly cordate, crenulated, equally dull green above and below; oil-glands pellucid; umbels solitary; stalklets none; fruits semiovate, border compressed, at the edge annular, valves barely inclosed. Bark thin, solid, slightly wrinkled.

43. **E. urnigera** Hook. Leaves scattered, long-stalked, almost lanceolar, crenulated, equally dark green; oil glands pellucid; umbels solitary; stalks elongated, stalklets rather short; fruits ellipsoid-urnshaped, border compressed, at the edge annular, valves deeply inclosed. Bark smooth, pale brown.

A small tree that endures low temperatures.

44. **E. platyphylla** F. v. M. Leaves often large, cordate or ovate roundish, long-stalked, equally dull green above and below; umbels solitary; stalks short, stalklets almost none; lid blunt; fruits small, semiovate, border depressed, valves exserted. Bark smooth and deciduous.

45. **E. stuartiana** F. v. M. Leaves scattered, stalked, equally dark green, shining; umbels solitary; few-flowered stalklets almost none; lid nearly hemispheric; fruits small, semiovate-top shaped, border narrow, rather convex, valves very small, exserted.

46. **E. viminalis** Hook. Leaves scattered, stalked, falcate-lanceolar, equally green

above and below; umbels solitary, mostly three-flowered; stalklets almost none or very short; lid semiovate, mostly short-pointed; fruit semiovate, border somewhat convex, valves exserted.

47. **E. rostrata** Schl. Leaves scattered, stalked, falcate-lanceolar, equally green above and below; umbels solitary, with several flowers; stalks rather elongated, stalklets conspicuous; lid from an hemispheric base sharp-pointed; fruit below semiglobular, border convex, valves exserted.

48. **E. tereticornis** Sm. Leaves scattered, stalked, falcate-lanceolar, equally green above and below; umbels solitary, with several flowers; stalks rather elongated, stalklets conspicuous; lid mostly elongate-conical; outer stamens straight in bud; fruits below semiglobular, border convex, valves exserted.

49. **E. macarthuri** D. and M. Leaves narrow, lanceolate, thickish, equally green above and below; umbels axillary and solitary, with several flowers; stalks short, stalklets very short or none; lid somewhat conical; fruits very small, nearly hemispherical, slightly dilated at the rim, valves usually three, scarcely exserted. Bark rough and woolly.

Prefers swampy or river-bottom land. Timber not very valuable.

50. **E. quadrangulata** D. and M. Leaves lanceolate, slightly falcate, usually 4 to 6 inches long, scarcely paler on the under surface; umbels axillary, solitary; stalks broadish and strongly compressed, stalklets none; lid somewhat conical; fruits small, shining, bell-shaped, valves usually three, slightly exserted. Bark rough and persistent, fuzzy.

51. **E. acaciaeformis** D. and M. Leaves lanceolate, of medium size, margins often crenulate, equally green; umbels solitary, with several flowers; stalks very angular or flattened, stalklets short and angular; lid slightly pointed; fruits small, elongate-hemispherical, valves scarcely exserted. Bark somewhat fibrous.

52. **E. rubida** D. and M. Leaves narrow-lanceolate, thickish, intramarginal vein scarcely removed from the edge, equally dull-green above and below; umbels solitary, three-flowered; stalks of medium length, stalklets very short or none; lid nearly hemispherical; fruits top-shaped or nearly hemispherical, rim convex, valves exserted. Bark smooth, falling off in strips.

Grows on mountain sides. Timber not valuable.

53. **E. gunnii** Hook. Leaves scattered, stalked, thick, broadish-lanceolar, equally dark green above and below, shining; umbels solitary, with several flowers; stalklets very short; lid shining, hemispheric, short-pointed; fruits topshaped-semiovate, border depressed, valves small, slightly exserted.

54. **E. rudis** End. Leaves thin, falcate-lanceolar, equally dull-green above and below; oil-dots pellucid; umbels solitary; stalklets short; lid broad-conical, transverse edge of the calyx prominent in bud; fruits semiglobular top-shaped, border rather convex, valves exserted.

55. **E. redunca** Sch. Leaves equally green above and below; umbels solitary; stalks broadly compressed, lid conical, acute; fruit hemiellipsoid, border compressed, valves inclosed. Bark smooth.

In good soil grows to a large size and furnishes valuable timber.

56. **E. salubris** F. v. M. Leaves thin, equally dark-green above and below; oil-dots numerous, pellucid; umbels solitary, stalks compressed; lid hemiellipsoid; fruits semiovate, border depressed, very narrow, valves small, exserted. Bark smooth and shining.

Promising for desert regions; endures high temperatures and considerable frost. Timber valuable. Leaves rich in oil.

57. **E. saligna** Sm. Leaves much paler beneath, veins feathery-spreading;

umbels solitary; stalk compressed, stalklets very short; lid hemispheric, short-pointed; fruit semiovate, border depressed, very narrow, valves small, exserted.

58. **E. resinifera** Sm. Leaves much paler beneath, veins very spreading; umbels solitary; stalk compressed; lid conical, acute; fruit semiovate, border depressed, narrow, valves exserted, pointed.

59. **E. punctata** DC. Leaves paler beneath, veins very spreading, oil dots pellucid; umbels partly paniculated; stalks broadly compressed; lid semiovate-conical; fruit semiovate, border depressed, valves small, barely exserted.

60. **E. planchoniana** F. v. M. Leaves elongated, shining, slightly paler beneath; umbels solitary; stalks broadly compressed, stalklets short; lid broadish-conical, acute; outer stamens straight in bud; fruits rather large, semiovate, streaked, border compressed, valves inclosed. Bark rough.

Promising for hot, dry regions free from frost. Furnishes abundant shade. Timber valuable.

61. **E. botryoides** Sm. Leaves much paler beneath, veins feathery-spreading; umbels solitary; stalk broadly compressed, stalklets almost none; lids hemispheric; fruit hemiellipsoid, border compressed, valves inclosed.

62. **E. goniocalyx** F. v. M. Leaves equally green above and below; umbels solitary, stalk compressed, stalklet very short; lid pyramidal-hemispheric; fruit truncate-ovate, angular, border narrow, depressed, valves inclosed.

63. **E. robusta** Sm. Leaves thick, broadish, somewhat paler beneath; umbels solitary, stalk broadly compressed; lid semiglobular-conical, broader than the calyx tube; fruit truncate-ovate, border compressed, valves coherent, inclosed.

64. **E. cornuta** Lab. Leaves lanceolate, equally green above and below; umbels solitary; stalklets almost none, lid very long, upward cylindrical; filaments yellow, long, straight in bud; fruit bell-shaped, semiovate, border depressed, valves exserted, very long, awl-shaped, coherent.

65. **E. occidentalis** End. Leaves thick, equally green above and below; umbels solitary; stalks broadly compressed, stalklets short; lid cylindric-conical; stamens straight in bud; fruits bell-shaped, semiovate, border depressed; valves exserted, pointed.

66. **E. longifolia** Lind. Leaves elongated, equally green above and below; umbels solitary, flowers in threes; stalklets elongated; calyces pale; lid broad-conical, acute; fruit rather large, bell-shaped, semiovate, angular, border ascendant, valves inclosed.

67. **E. globulus** Lab. Leaves thick, elongated, equally green above and below; flowers mostly solitary, stalks and stalklets almost none; lid double, the inner crown-shaped; fruit large hemispheric, warty-rough, angular, border broad, depressed, valves exserted, convergent.

68. **E. gomphocephala** DC. Leaves thick, shining, slightly paler beneath; umbels solitary; stalk broadly compressed, stalklets none; lid broader than the tube of the calyx, almost hemispheric; fruit large, top-shaped, border broad, convex, valves exserted, convergent.

BIBLIOGRAPHY OF THE GENUS EUCALYPTUS.

The principal papers and books upon the genus Eucalyptus are listed below. It will be noted that the majority of the papers have been published in French scientific journals. Many others bearing upon pharmaceutical and hygienic questions pertaining to Eucalypts have appeared in European, American, and Australian periodicals.

Several works not listed below are devoted in part only to a discussion of some phase of the genus.

Aberg. *Irrigacion y Eucalyptus.* Buenos Ayres. 1874.

Andre. *L'Eucalyptus globulus.* Revue horticole. 1863.

Bailey. *Contributions to the Queensland Flora.* Brisbane. 1896.

—— *Queensland Woods.* London. 1899.

Bentham & Mueller. *Flora Australiensis.* Vol. III. London.

Bertheraud. *L'Eucalyptus au point de vue l'hygiene en Algerie.* Alger. 1876.

Brunel. *Sobre el Eucalyptus globulus.* Revista medico quirurgico. Buenos Ayres. 1873.

Buton. *L'Eucalypto.* Bologna. 1875.

Carlotti. *De la culture de l'Eucalyptus en Corse.* Bulletin de la Société d'Acclimatation de Paris. 1866.

—— *L'Eucalyptus globulus.* Ajaccio. 1870.

—— *Assainissement des regions chaudes insalubres par l'Eucalyptus.* Ajaccio. 1875.

—— *L'Eucalyptus en Corse.* Bulletin de la Société d'Acclimatation de Paris. 1877.

Certeux. *Guide du planteur d'Eucalyptus.* Alger. 1877.

Combes. *L'Eucalyptus et ses derives.* Paris. 1895.

Cooper. *Forest culture and Eucalyptus trees.* San Francisco. 1876.

Cordier. *Des Eucalyptus.* Bulletin de la Société d'Agriculture d'Agen. 1874.

—— *L'Eucalyptus en Algerie.* Bulletin de la Société d'Acclimatation de Paris. 1876.

Deane & Maiden. *Observations on the Eucalypts of New South Wales.* Proceedings of the Linnean Society of New South Wales. 1895–1902.

Fedfli. *Sulle proprietá bonificante, et terapeutiche del l'Eucalyptus globulus.* Forli. 1876.

Gastinel-Bey. *Memoire sur l'Eucalyptus globulus d'Australie.* L'Egypte Agricole. 1870.

Gildas. *L'Eucalyptus dans la campagne romaine.* Bulletin de la Société d'Acclimatation de Paris. 1875.

Gimbert. *L'Eucalyptus globulus; son importance en agriculture, en hygiene, en medicine.* Paris. 1870.

—— *Etude sur l'influence des plantations d'Eucalyptus globulus.* 1875.

Jolly. *Les Eucalyptus géants de l'Australie.* Paris. 1885.

Kinney. *Eucalyptus.* Los Angeles. 1895.

Lambert. *Eucalyptus: culture, exploitation, et produit.* Bulletin de la Société d'Acclimatation de Paris. 1872.

Maillard de Marafy. *L'Eucalyptus: nouvel emploi industriel.* L'Egypte Agricole. 1870.

Mares. *Note sur l'Eucalyptus.* Alger. 1870.

Maiden. *Useful Australian Plants.* Agricultural Gazette of New South Wales. 1893–1900.

—— *Notes on the Commercial Timbers of New South Wales.* Sidney. 1895.

—— *The Forest of New South Wales.* Agricultural Gazette of New South Wales. 1901.

MERICE. *Progres et development de la culture de l'Eucalyptus.* Bulletin de la Société L'Acclimatation de Paris. 1874.

MONCHALAIT. *Eucalyptus.* Bulletin de la Société L'Acclimatation de Paris. 1867.

MUELLER. *Fragmenta phytographiae Australiae.* Melbourne. 1858–1875.

—— *Australian vegetation, indigenous and introduced.* Melbourne. 1866.

—— *Eucalyptographia.* Melbourne. 1879–1884.

NARDY. *Les Eucalyptus du littoral de la mediterranée.* Journal de la Societé Centrale d'Horticulture de France. 1875.

NAUDIN. *Les Eucalyptus entroduits dans la region mediterranéenne.* Antibes. 1883.

—— *Description et emploi des Eucalyptus introduits en Europe.* Antibes. 1891.

PASQUIER. *De l'Eucalyptus.* Chateau-Gontier. 1873.

PHILLIPE. *Sur l'Eucalyptus globulus.* Bulletin de la Société d'Acclimatation de Paris. 1862.

PIETRA-SANTA. *Influence de l'Eucalyptus en Algerie et en Corse.* La Nature. 1877.

PLANCHON. *L'Eucalyptus globulus an point de vue botanique economique et medical.* Revue des deux mondes. 1875.

—— —— Translated into English by the United States Department of Agriculture. 1875.

POLLI. *Sull' Eucalipto.* Milano. 1876.

RAMEL. *Sur les Eucalyptus oleosa et globulus.* Bulletin de la Société d'Acclimatation de Paris. 1861.

—— *L'Eucalyptus globulus de Tasmanie.* Revue maritime et coloniale. 1861.

—— *L'Eucalyptus globulus.* Bulletin de la Société d'Acclimatation de Paris. 1862.

RAVERET-WATEL. *L'Eucalyptus; Rapport sur son introduction, sa culture, ses proprietes, usages, etc.* Bulletin de la Societé d'Acclimatation de Paris. 1871, 1872.

—— *L'Eucalyptus et son avenir.* Bulletin de la Societé d'Acclimatation de Paris. 1873.

SAHUT. *Les Eucalyptus.* Montpelier. 1888.

SOUSA-PIMENTEL. *Eucalypto globulus; descripção, culture aproveitamento d'esta arvore.* Lisboune. 1884.

TROTTIER. *Boisement dans le désert et colonisation.* Alger. 1869.

—— *De l'accroiscement et de la valeur progressive de l'Eucalyptus.* Alger. 1871.

—— *Arbres de l'Australie.* Alger. 1872.

—— *Role de l'Eucalyptus en Algerie.* Alger. 1876.

WOOLLS. *A contribution to the Flora of Australia; the genus Eucalyptus.* Sidney. 1867.

—— *The Plants of New South Wales.* Sidney. 1885.

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